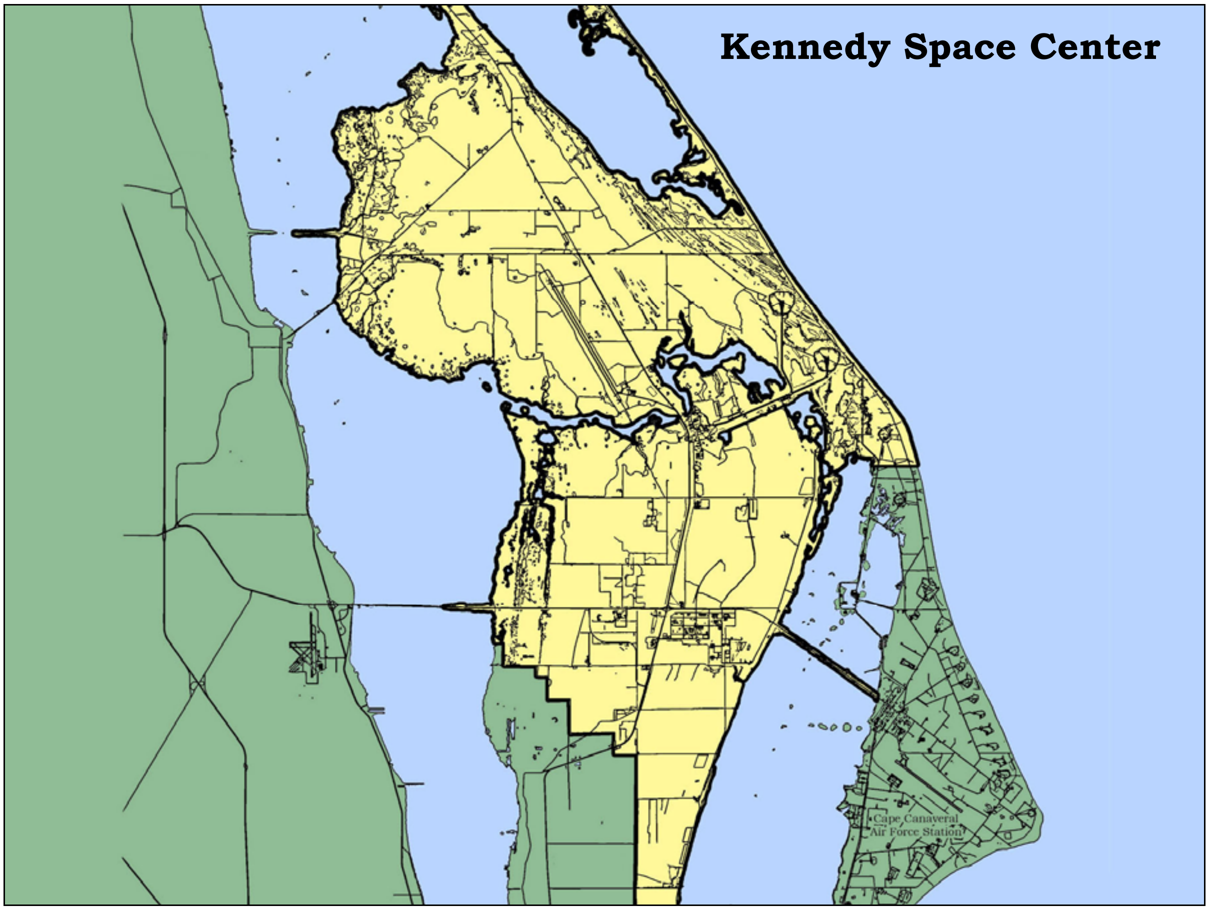

KSC Vertical Launch Site Evaluation

17AUG07

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REVISION B, 26OCT07

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Section I: Executive Summary

RS&H was tasked to evaluate the potential available launch sites for a combined two user launch pad. The Launch sites were to be contained entirely within current Kennedy Space Center property lines.
The user launch vehicles to be used for evaluation are in the one million pounds of first stage thrust range. Additionally a second evaluation criterion was added early on in the study. A single user launch site was to be evaluated for a two million pound first stage thrust vehicle. Both scenarios were to be included in the report.

To provide fidelity to the study criteria, a specific launch vehicle in the one million pound thrust range was chosen as a guide post or straw-man launch vehicle. The RpK K-1 vehicle is a current Commercial Orbital Transportation System (COTS), contract awardee along with the SpaceX Falcon 9 vehicle. SpaceX, at the time of writing, is planning to launch COTS and possibly other payloads from Cx-40 on Cape Canaveral Air Force Station property. RpK has yet to declare a specific launch site as their east coast US launch location. As such it was deemed appropriate that RpK's vehicle requirements be used as conceptual criteria. For the purposes of this study those criteria were marginally generalized to make them less specific.

1.1 Evaluation Approach

To provide a comparative contrast for two launch providers the users were referred to as User A and User B. The modified RpK requirements were applied to User A.

A brief summary of the RpK K-1 criteria is as follows:

- Only vehicle integration and launch requirements were assessed. Reusability and recovery of flight components were not a part of this study.
- Horizontal processing and integration of vehicle components for User A.
- Horizontal transport to the pad on rails for User A.
- Erection of vehicle to vertical at the pad for User A.
- Commodities, propellants and gases needed for processing and fueling, are based upon the K-1 vehicle requirements. Coincidentally the type and quantity of those are similar to those required for the SpaceX Falcon 9 vehicle.

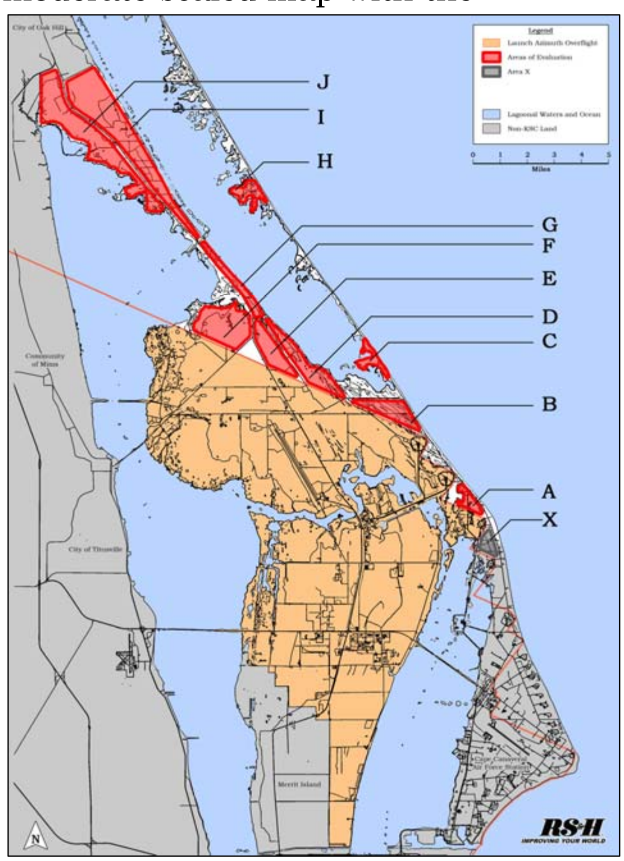
Criteria adopted for User B is:

- Vertical processing and integration of vehicle components for User B.
- Vertical transport to the pad on rails for User B.
- Commodities, propellants and gases needed for processing and fueling the User B vehicle are also based upon the K-1 vehicle requirements.

A third entity, The Advanced Technology Development Center (ATDC), currently residing at Cx-20, CCAFS, was to be considered as to what affect its inclusion would have on the overall site development plan.

From the above considerations a prototype site plan was developed. The plan includes all of the above elements and incorporates the current Quantity Distance (QD) circles calculated for commodity storage. QDs for integrated, fueled vehicles were obtained using those from the Atlas V and Delta IV programs. These are conservative values for use with a one million pound thrust vehicle and are within the required range for a vehicle with two million pounds of thrust. The prototype plan is shown in Figure 9 on page 18.

The shapes of the available land areas did not readily lend themselves to being mapped on a Cartesian grid. To separate the potential areas for study the areas were thence chosen from a moderate scaled map with the following criteria:



- No attempt was made to prejudge any area.
- The minimum size of any area to be considered appears large enough to accommodate the Typical Site Layout shown in Figure 7 on page 18.
- Some delineating man-made or natural geophysical or political feature divided one from another.

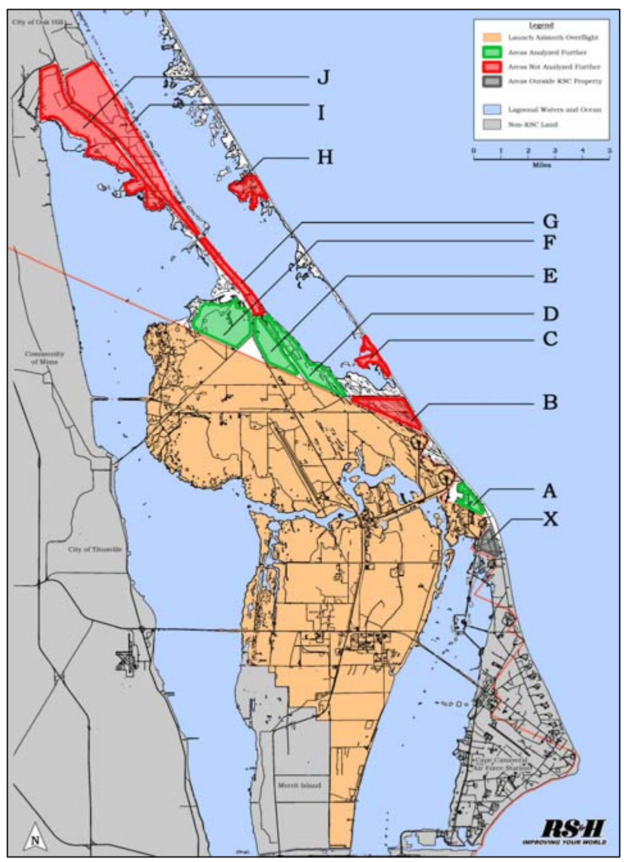
This resulted in the eleven identifiable areas shown in the figure at the right.

Next a series of criteria were developed by which KSC property could be evaluated for its potential use as a launch site. A certain few of those were of a Pass/Fail type. The pass/fail criteria were applied to previously designated KSC available land first as that greatly reduced the number of areas requiring further evaluation.

Those initial pass/fail evaluation parameters are:

- No over-flight of other facilities is allowed, yet the launch area must provide the full array of launch azimuths available for the Eastern Range.
- The area must be 5 miles or greater from residential areas.
- The area must not be inundated by a Category One hurricane storm surge.
- Must contain a minimum of 150 contiguous acres for development.

Application of these criteria reduced the land for further evaluation to four areas, as shown in the figure below.



The remaining areas were evaluated further with criteria spanning a wide array of topics from Range Safety lines of sight and proximity to populated areas to Archeological constraints and proximity to utilities. For each of the four remaining areas, each criteria item was given a value of 1 to 5 in relation to its standing with the other areas, with 5 being the most favorable value. Additionally, each line item was given a weighted value that governs its relative influence on the final score.

Of the four areas, the two with the highest scores are identified as the best candidate areas for further evaluation. Area A has a score some 8 percent higher than the next lowest scoring area, Area E, and 14 and 25 percent higher respectively than the remaining two areas.

Area A Boundaries

North	Pad 39A perimeter
East	Atlantic Ocean
South	Cx-40 perimeter and Cx-40 Flyover Constraint
West	Primarily the CCAFS rail road tracks and ultimately Gulbrandson Creek

Area E Boundaries

North	Existing road/trail 0.7 mi North of Confluence of A Max Brewer Memorial Parkway and SR-3
East	Existing road/trail parallel to Kennedy Parkway North (SR-3)
South	Over-flight line from Pad 39 B
West	State Road 3

1.2 Cost

Based upon the prototypical site plan parameters, a unique conceptual site plan was then developed that fit into each area. Individual cost estimates were then developed. Since the new launch facilities are essentially the same for both sites, the cost differential between sites is dependant upon the site work and mitigation issues (wetlands, habitat and archeological) specific to each site.

As vehicle criteria requirements were met with conceptual designs and as each area was evaluated it became clear that the inclusion of a two million pound thrust vehicle was a matter of marginal incremental changes rather than the anticipated large magnitude change. Cost estimate deltas for the two million pound thrust vehicle were obtained by increasing commodities storage and system costs by eighty percent. Most other facilities exhibited little significant change to support the larger thrust vehicles.

The cost estimates represented here are Rough Order of Magnitude (ROM) estimates. They are in 2007 dollars and are based upon criteria estimated from the best information available. The estimates are speculative and useful for ROM overall cost diagnosis and for comparison of one to another. They are not to be construed as construction estimates. The costs derived herein are based on previous government costs for similar facilities and services. These facilities and services have been executed in ways and methods normal to the national space program to date. The burgeoning group of commercial launch providers has many different methods that are innovative and alleged to be cost effective. It is then anticipated that when dealing with specific rather than generalized criteria and with methods and processes different from the norm these costs will change.

Costs include:

User A

- One horizontal vehicle processing facility including the rails to the launch pad, the transporter and facility related GSE
- One launch pad with umbilical mast and mechanism to erect the vehicle to vertical

User B

- One vertical vehicle integration facility including the rails to the launch pad, the transporter and facility related GSE
- One launch pad with umbilical mast

Both users

- Site preparation including environmental and archeological studies and mitigation
- Commodity storage and delivery systems
- Common office/administration/control facility
- Common maintenance facility
- Design costs for above

Does not include:

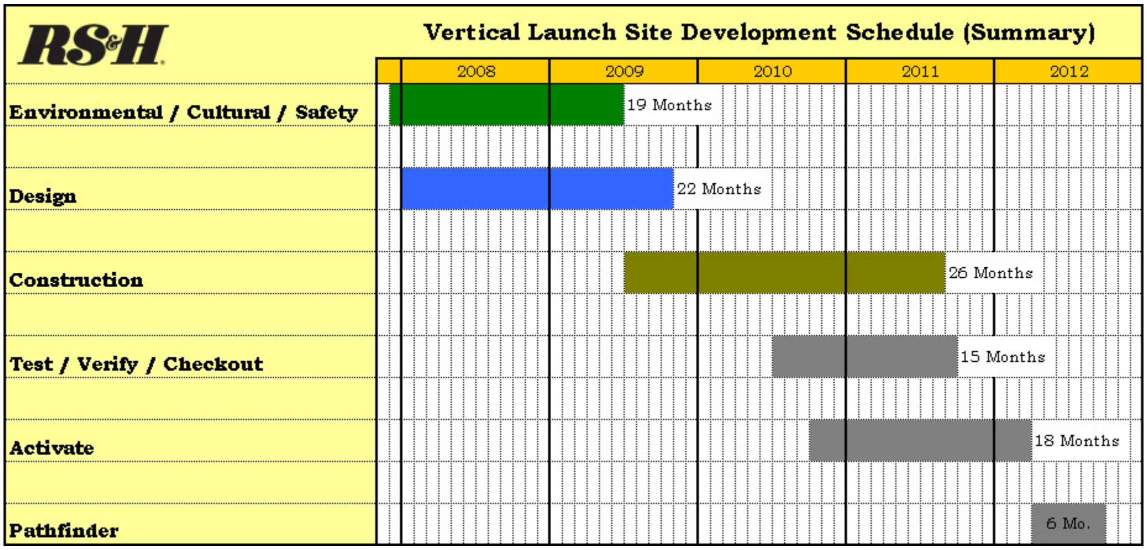
- Vehicle specific GSE, handling fixtures, control panels and skids
- Costs for preparing flight approval documentation
- Launch Control Center
- Software development.

Cost Summary RS&H		
Vertical Launch Site ~ Two User		
Total Facility Cost (in 2007 $Millions)	One Million Pound Thrust Vehicles	Two Million Pound Thrust Vehicles
Site in Area A	**$ 507M**	**$ 590M**
Site in Area E	**$ 504M**	**$ 588M**

Cost Affect of the Addition of ATDC

The addition of ATDC resources and requirements will likely be a net site cost reduction. Since there is an assumed central control building and maintenance building requirement the ATDC personnel and equipment could fit into those spaces with minimal expansion. The use of their existing tanks and hardware would significantly reduce commodities system costs and reduce some long lead item schedules. None of these items have been evaluated with enough detail to quantify.

1.3 Schedule



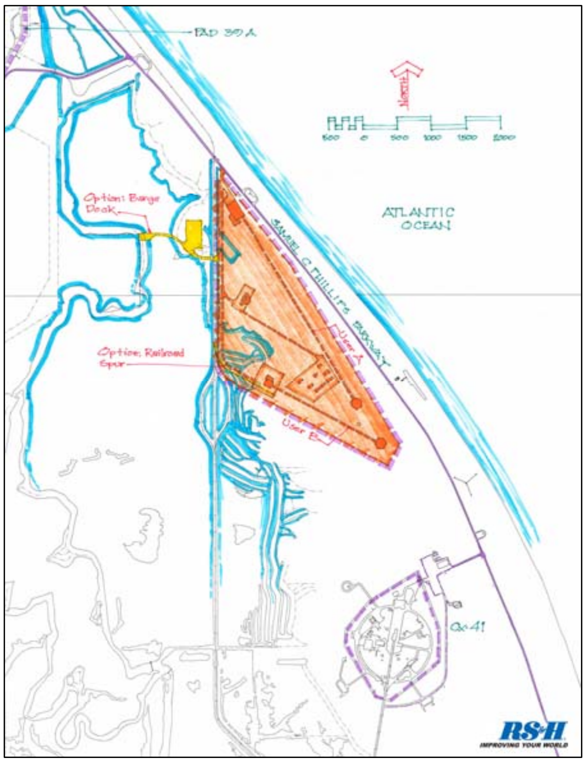
The schedule shown above is valid for either site. No site work can begin without prior environmental/safety approval. Preliminary design is initiated two months prior to beginning the approval process. The program is anticipated to have acquired enough data by December of 2007 to begin environmental and safety reviews. Final design for the facility is shown to be simultaneous with the approval process. These approvals are expected to be complete in 19 months when construction can begin on the site. To reduce schedule length, Testing/Verification/Checkout activities as well as Activation begin as soon as possible before completion of construction. The complete schedule from Preliminary Design to Operational Readiness requires approximately 5 years.

1.4 Recommended Site

The schedule is the same for a site developed at either Area A or Area E. The cost differential between the two sites is less than one percent which at this stage of conceptual development is well below the “noise” level of accuracy. Neither the schedule nor the cost then can be deemed a discriminating factor.

Through the evaluation process Area A gained the highest score. It is in several of the line items wherein it gained those scores that perhaps make’s it more attractive than would be indicated merely by the score. They are as follows:

- Area A is located directly on the coast thus greatly mitigating the effects of any potential debris fields on neighboring facilities.
- Area A is located within the existing KSC fence thus reducing security concerns and security operations costs.
- Area A does not over-fly or directly affect any existing public recreational areas.



Recommended:

The outcome of this study is a recommendation for initiating the processes to establish a new vertical launch site at Area A, adjacent to the Samuel C. Phillips Parkway, north of Pad-41 and south of Pad 39A.

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Table of Contents

List of Figures

List of Tables

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Section II: Introduction

2.1 Introduction

Reynolds, Smith, and Hills (RS&H) was tasked by NASA, under NASA Project ID 98676, to perform a review of available documents and contact with select KSC representatives to complete an appropriate analysis for "A Study of KSC Vertical Launch Site Evaluation". This study investigates the current KSC conditions and anticipates future configurations after the close of the Space Shuttle Program.

Excerpts of the SOW are reproduced below to delineate the tasks of this study.

"The purpose of the study is to evaluate and suggest potential vertical launch sites within the property of KSC. Provide professional services in support of this topic, in the form of examination of existing in house data on the sites, collection of new data, analysis, planning and site selection recommendations in a readily useable, comparative form."

Additional requirements include choosing two sites that are the most promising after evaluation and comparison and developing program costs and schedules for each site. Each site will be investigated as a launch site for:

- Two vehicles in the small to low end medium size vehicle category site, called the Two User Evaluation or 1 Mlb Thrust Evaluation.
- One vertical launch site with a first stage thrust in the two million pound range, called the 2Mlb Thrust Evaluation.

This study will also address and delineate the affects of accommodating the Advanced Technology Development Center (ATDC) at either of the above sites.

2.2 Organization

This study is organized toward recommending at least two vertical launch sites within the KSC boundaries. To establish two viable sites from all possible sites, criteria were developed to aid in sorting through diverse information from a variety of sources. The sizes of vehicles anticipated to use the chosen sites are in the Delta II/Atlas II range of vehicles, which limits the payload to low earth orbit capability of the group to approximately 20,000 lbm or less to LEO. Also within that range is the RpK K-1 vehicle at an advertised 10,000 lbm and the SpaceX Falcon 9 at an advertised 20,100 lbm to LEO. The other class of vehicle to be evaluated is the 2Mlb thrust vehicle range.

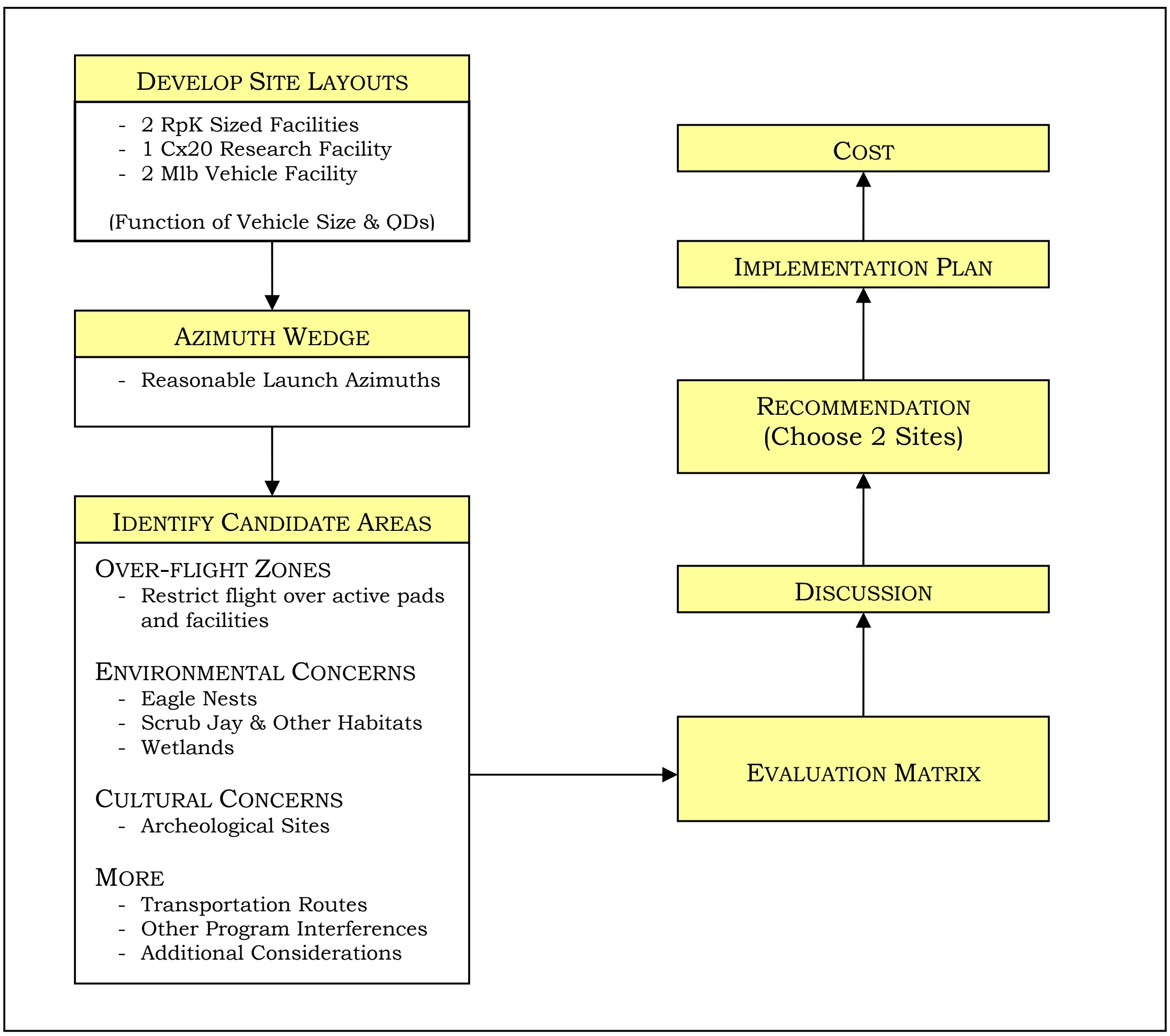

Figure 1: Analysis Flow Diagram

To establish a "strawman" launch site user within the class of vehicles chosen, the RpK K-1 vehicle was utilized. At the time of this writing the K-1 vehicle is one of the current vehicles being considered for the COTS contract award along with the SpaceX Falcon 9. SpaceX is, at the time of writing, considering the use of Cx-40 at CCAFS for their COTS and possibly other launches. RpK has yet to formally consider a specific launch site on the east coast of the United States for their COTS launch site, thus using K-1 vehicle requirements as development criteria makes sense since there exists a potential for immediate use. The vehicle requirements used herein have been generalized so as not to preclude other potential users in the million pounds of thrust range of vehicles.

Per the SOW, this study is divided into the following sections:

Section I: Executive Summary
Section II: Introduction
Section III: Vehicle Size Range/Class and Requirements
Section IV: Definition of the Vertical Launch Site Limits
Section V: Vertical Launch Site Survey
Section VI: Initial Site Evaluation
Section VII: Further Site Analysis
Section VIII: Cost Estimates
Section IX: Schedule
Section X: Recommended Vertical Launch Site Options at NASA-KSC
Section XI: Notes and Backup Data

2.3 Submittal Type

This is a “Final” submittal. No further submittals will be made.

2.4 Invitation for Comment

Please direct your written comments and questions regarding this study to:

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E-mail Address: david.keller@rsandh.com

2.5 Acronyms

A-E	Architect/Engineer
AE	Ammunitions and Explosives
ADC	Aircraft Design Group
ATDC	Advanced Technology Development Center
CCAFS	Cape Canaveral Air Force Station
CFM	Cubic Feet per Minute
CLV	Crew Launch Vehicle
COTS	Commercial Orbital Transportation Services
CX	Complex
DOD	Department of Defense
EBS	Environmental Baseline Survey
ECCP	Estimated Construction Contract Price
EDC	Engineering Document Center
EELV	Evolved Expendable Launch Vehicle
EIS	Environmental impact Statement
ER	Eastern Range
EWR	Eastern / Western Range
FAA	Federal Aviation Administration
GHe	Gaseous Helium
GLOW	Gross Liftoff Weight
GN2	Gaseous Nitrogen
GOX	Gaseous Oxygen
gpm	Gallons per minute
GSE	Ground Support Equipment
IBD	Inhabited Building Distance
ICD	Interface Control Document
IHB	Inhabited Building
ILD	Intra-line Distance
IMD	Inter-magazine Distance
ITAR	International Traffic and Arms Regulation
KSC	Kennedy Space Center
LAP	Launch Assist Platform
lbm	Pounds, mass
LC	Launch Complex
LCC	Launch Control Center
LEO	Low Earth Orbit
LH2	Liquid Hydrogen
LN2	Liquid Nitrogen
LOS	Lines of Sight
LOX	Liquid Oxygen
Mlb	Million Pounds

MMH	Monomethyl Hydrazine
MST	Mobile Service Tower
N2O4	Nitrogen Tetroxide
NASA	National Aeronautics & Space Administration
NFPA	National Fire Protection Association
NRO	National Reconnaissance Office
OFZ	Object Free Zone
OMS	Orbital Maneuvering System
ORD	Operational Readiness Date
OV	Orbital Vehicle
PCN	Project Control Number
PM	Project Manager
PTRD	Public Transportation Route Distance
QD	Quantity Distance
R&D	Research & Development
ROCC	Range Operations Control Center
ROM	Rough Order of Magnitude
RpK	Rocketplane-Kistler
RPZ	Runway Protection Zone
RS&H	Reynolds, Smith & Hills
RSA	Runway Safety Area
SBU	Sensitive But Unclassified
SCFM	Standard Cubic Feet per Minute
SEIS	Site Engineering and Inspection Services
SLF	Shuttle Landing Facility
SOW	Statement of Work
SR	State Road
STD	Standard
TBD	To Be Determined
UDMH	Unsymmetrical Dimethyl Hydrazine
US	United States
VAB	Vehicle Assembly Building
VIF	Vehicle Integration Facility
VPF	Vehicle Processing Facility
45SW	45^{th} Space Wing (Air Force)

2.6 Sources

Documents

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[2] **K-1 Facilities/Systems & Processing Manual**, Kistler Aerospace Corporation, 2001.

[3] **K-1 Concept of Operations (ConOps) Document for the NASA Commercial Orbital Transportation Services (COTS) Program,** Rocketplane Kistler, (DRAFT) 08JAN07

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[9] **International Reference Guide to Space Launch Systems: Fourth Edition**, Steven J. Isakowitz, Joseph P. Hopkins Jr., Joshua B. Hopkins, AIAA, 2004

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[19] **Launch Complex 39B Remediation Fact Sheet,** KSC-TA-7619

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Website

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(B) **Orbital Science Website,** http://www.orbital.com/NewsInfo/Publications/Taurus_fact.pdf, 2007

(C) **Cultural Resources Management Website at KSC,** http://environmental.ksc.nasa.gov/projects/cultural.htm, 2007

Via Direct Dialogue

(AA) **Federal Aviation Administration, North Florida Flight Standards District Office,** Juan Brown.

(AB) **Constellation Program Interference**, Scott Colloredo, LX-D2 and Hector Delgado, NE-D, NASA.

(AC) **Environmental/Cultural Issues**, Mario Busacca, TA-C3, Kim Manguikian, TA-C3 and Renee Ponik, TA-D5, NASA.

(AD) **Federal Aviation Administration, Commercial Space Transportation Safety Office,** Al Wassel, Patrick Air Force Base

2.7 Assumptions

The assumptions used for this analysis are as follows:

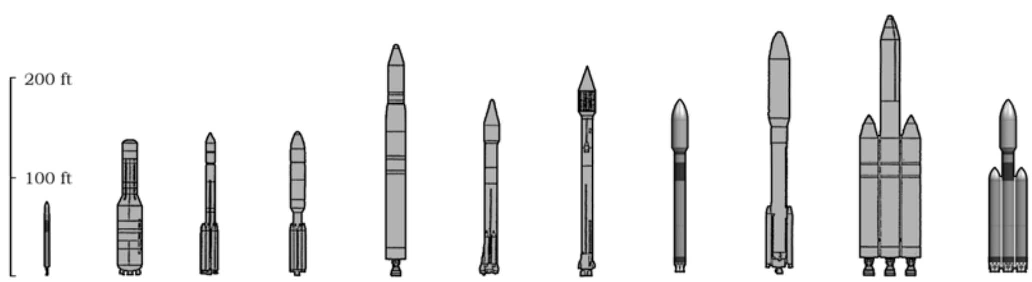
- The study will evaluate vertical launch sites only. Landing or flight component recovery facilities are not included.
- Candidate areas will be on KSC property.
- Large tracts of land under evaluation are given letter designations and referred to as Areas.
- The actual land delineated for development within an Area will be called a Site.
- Initial site evaluation will be for a launch site to accommodate two launch users with vehicles with a maximum thrust of approximately one million pounds.
- A secondary evaluation will be to evaluate a site for two million pound thrust vehicles.
- Consideration will be given to possible inclusion of the Advanced Technology Development Center (ATDC). While the inclusion of ATDC is not a requirement, it has not been precluded.
- The RpK K-1 vehicle will be loosely used as a model for the one million pound thrust vehicle and for facilities sizing.
- Commodity storage and distribution will be sized according to RpK K-1 requirements with generalizations toward more generic vehicles.
- A specific user(s) has not been selected. Without definitive criteria from a specific user, the commodities delineated for the site will include all liquid propellants currently in use for orbital vehicles in the USA in addition to those proposed for the RpK vehicle.
- One vehicle, with one million pounds of thrust (based upon the RpK K-1 vehicle), will be shown with horizontal vehicle processing and integration including horizontal transport to the pad with erection to vertical occurring at the pad
- For comparative diversity the second vehicle will be depicted with vertical processing and integration, and vertical transport to the pad
- Payload's and their fairings and cargo modules are processed in off-site facilities. They are brought to the site encapsulated and ready for integration to the launch vehicle
- The launch control area for this study is assumed to be the NASA LCC at the VAB complex. At each candidate site duct banks are run from the site to the LCC. Costs in Section 8 reflect that installation.

Section III: Vehicle Size Range/Class and Requirements

This section contains information related to the sizes and classes of launch vehicles considered for review in this study as well as related information to the explosive quantity distances and a conceptual launch facility site layout. Several US launch vehicles are presented with comparative data used to separate them into two columns for analysis. Following this comparison, a description of the Rocketplane-Kistler (RpK) K-1 vehicle is provided, including its commodity storage requirements. Using these requirements, quantity distance explosive separations are calculated and a generic conceptual launch facility site layout is provided with descriptions of integration and support facilities. Quantity distance circles for integrated vehicles were obtained from the distances used for the Atlas V and Delta IV programs.

3.1 Launch Vehicle Sizes and Performance

The site selection criteria will be to accommodate two specific sites. The first is for medium sized vehicles of the Delta II/Atlas II and low end of the Evolved Expendable Launch Vehicle (EELV) range. An RpK K-1 vehicle (1 million pound thrust) will be used as a "strawman" vehicle as RpK is currently in search of an east coast launch site and can provide the most complete data regarding vehicle requirements. This vehicle is used as a gauge for relative facility size and processing accommodation for the two user site. The second will be for 2 million pound thrust vehicles.



Launch Vehicle	Falcon 1	K-1	Delta II	Delta III	Delta IV Medium	Atlas IIAS	Atlas IIIB	Falcon 9	Atlas V 500	Delta IV Heavy	Falcon 9 Heavy
Payload LEO (klb)	1.2	10.1	11.3	18.2	18.6	19.0	23.6	21.8	44.2	56.9	60.6

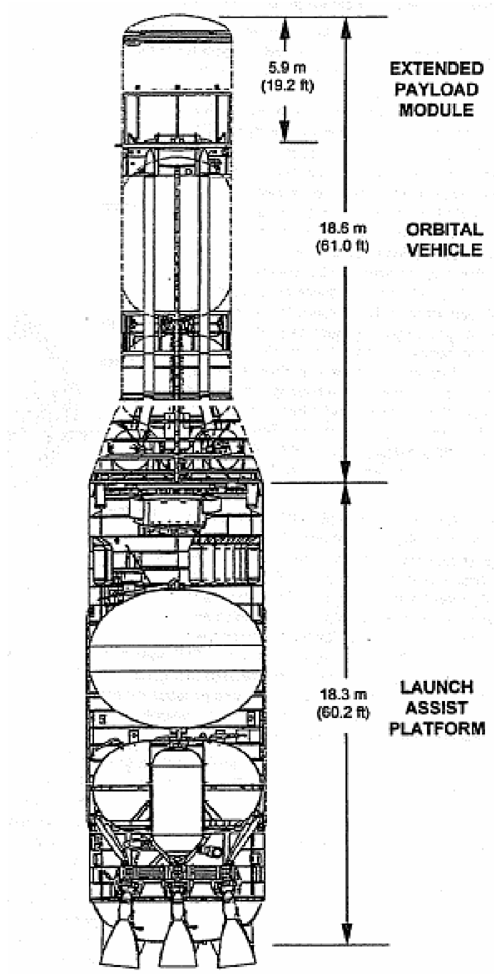
Figure 2: Relative US Launch Vehicle Sizes and Performance

Table 1: Relative US Launch Vehicle Sizes and Performance

Launch Vehicle	LEO Max lbm	Height ft	GLOW lbs	Thrust lbs	Potentially Included in: 1 Mlb Thrust Evaluation	Potentially Included in: 2 Mlb Thrust Evaluation
Athena II	4,520	74	--	325,900	✓	
Atlas IIAS	19,000	156	522,900	676,200	✓	
Atlas IIIB	23,630	174	495,600	585,000	✓	
Atlas V 400	27,550	191	734,800	860,200	✓	
Atlas V 500	44,200	204	1,191,200	2,155,000		✓
Atlas V Heavy	55,100	214	--	2,580,000		✓
Delta II	11,330	141	--	1,100,000	✓	
Delta III	18,280	130	--	1,280,000	✓	
Delta IV Medium	18,600	212	--	650,000	✓	
Delta IV Medium Plus	30,000	220	--	1,415,600		✓
Delta IV Heavy	56,900	220		1,950,000		✓
K-1	10,150	121	841,000	1,020,000	✓	
Commercial Taurus	3,040	104	170,000	361,000	✓	
Falcon I	1,250	70	77,200	102,000	✓	
Falcon 9	21,800	154	716,000	764,350	✓	
Falcon 9 Heavy	60,600	174	1,950,000	2,750,000		✓
Additional US Launch Vehicles for Reference						
BA-2	37,400	212	2,100,000	3,170,000		
Minotaur	1,408	63	79,800	178,000		
Pegasus XL	977	55	51,000	163,000		
Titan II	4,200	148	340,000	474,000		
Titan IVB	47,800	204	2,040,000	3,400,000		

The above table lists varying sizes of launch vehicles along with performance parameters. Some of the vehicles listed are no longer in use and are provided for reference. The columns on the right identify how these launch vehicles relate to this study. The majority of the launch vehicles listed with thrusts less than 1.4 million pounds are potentially accommodated by the size of facilities investigated for 1 Mlb Thrust Evaluation The launch vehicles listed with thrusts greater than 1.4 million pounds are potentially accommodated by the size of the facilities investigated for “2 Mlb Thrust Evaluation.” The purpose of this table is to provide relative launch vehicle information for the size and class of launch vehicles that fit into the evaluations initiated in this study.

3.2 RpK K-1 Vehicle Baseline



Parameter	Magnitude
Height	36.9m (121.2 ft) with extended payload module
Diameter	LAP: 6.7m (22 ft) OV: 4.3m (14 ft)
Gross Liftoff Mass	382 metric ton (842,000 lbm)
Thrust at Liftoff	4540 kN (1,021,000 lbf)
Thrust to Weight Ratio	1.21 to 1

The Rocketplane-Kistler K-1 vehicle shown above is a two stage reusable launch vehicle that is designed to return to the general vicinity from which it was launched. The goal of the designers is to achieve 100 flights from a single launch vehicle. Both the first stage and the second stage are powered by LOX and RP grade Kerosene. The first stage is known as the Launch Assist Platform (LAP) and contains three main engines. The center main engine is an Aerojet AJ26-59, while the two outboard engines are Aerojet

AJ26-58's. Of the three engines, only the center engine (AJ26-59) is designed to restart for returning to the landing site, the other ones are single-start only.

The second stage of the K-1 is known as the Orbital Vehicle (OV) and contains a single main engine and an Orbital Maneuvering System (OMS). The main engine for the OV is an Aerojet AJ26-60. The OMS uses LOX and ethanol as its propellants as opposed to the typical hypergolic combination UDMH and N_2O_4. In comparison to LOX and ethanol, hypergols are hazardous, highly toxic and invoke safety issues in storage, transfer and ground processing.

Table 2: Commodity Storage Capacity Requirements for K-1 Vehicle at Pad

Commodities	**Vehicle** (gal)	**Support** (gal)	**Reserve** (gal)	**Storage for 1 Launch** (gal)
LOX	56,500	10,000	23,500	90,000
RP	31,000	0	4,000	35,000
LN2	450	72,000	12,550	85,000
Ethanol	500	0	100	600
GOX,	0	2,618	393	3,011
GN2, Press. A	0	1,824	274	2,098
GN2, Press. B	0	748	112	860
GN2, Press. C	751	0	0	0
GHe, Press. A	0	1,360	204	1,564
GHe, Press. B	0	1,646	247	1,893
GN2, Press. C	843	0	0	0

In addition to meeting the above vehicle requirements, storage tank commodities are chosen to support an additional unknown user with unknown requirements. As such not all commodities and capacities discussed below are required by the K-1 vehicle. Some additional items are a function of possible inclusion of ATDC facilities or requirements from a yet to be defined second launch supplier in the proposed site plan.

Each tank at the launch site will contain enough of its commodity for one complete launch, the vehicle's tanks' needs, support quantities, and reserve quantities including two abort de-tankings before commodities replenishment is required. When a reserve requirement could not be found for the gaseous tanks, 15% was added as reserve. Note that the vehicle's lower pressure tanks have a 0 gal GSE tank requirement as they are loaded from the GSE tanks with higher pressures that are reduced to the required lower pressure. Cryogenic storage commodities are sized to account for two vehicle de-tankings/three re-tankings with storage tank reserve to avoid a thermal cycle on the storage tanks.

K-1 Facilities RP Storage

The new rocket propellant tank will be sized for 35,000 gal. The facility will be capable of cooling the fuel to -35°F for launch. Any water in the fuel will be removed prior to the fuel loading of the vehicle through a freezing and filtering process.

K-1 Facilities LOX Storage

The new liquid oxygen tank will be sized for 90,000 gallons and is kept at -320°F.

K-1 Facilities LN2 Storage

The new liquid nitrogen tank will be sized for 85,000 gallons.

K-1 Facilities Ethanol Storage

The new ethanol tank will be sized for 600 gallons. The ethanol for the LAP and OV will be loaded on the vehicle before it is transported to the pad.

K-1 Facilities GOX Storage

The new gaseous oxygen tube bank will provide 3,000 gallons of GOX.

K-1 Facilities GN2 Storage

Two new gaseous nitrogen tanks will service the launch operations. One of the tanks will be sized for 900 gal. The other GN2 tank at a different pressure will be sized for 2,100 gallons of nitrogen.

K-1 Facilities GHe Storage

Two new gaseous helium tanks will service the launch operations. One tank will be sized for 1,900 gallons. The second tank, at a different pressure, will be sized for 1,600 gallons.

ATDC Facilities LH2 Storage

Should ATDC development testing be included in the site plan, a liquid hydrogen tank of 60,000 gallons capacity is required. Obtaining this capacity will be accomplished through the use of the two existing 30,000 gallon tanks at the ATDC facility at Cx-20 piped together.

3.3 Quantity Distance Information

Propellant and commodity needs of the second launch user are unknown at the time of writing. To maintain a conservative approach, all currently used propellants in the United States are included in the site and tank plans. There will be five major propellants located at the tank farm for the launch site:

- Nitrogen Tetroxide (N_2O_4)
- RP-1
- Liquid Oxygen (LOX)
- Liquid Hydrogen (LH2)
- Hydrazine (UDMH)

Table 3: Various Propellants Considered for Two User Evaluation of 1 Mlb Thrust Vehicle

Propellant	**Type**	**Volume** (gal)	**Mass** (lbs)
RP-1	Fuel	73,900	724,500
Nitrogen Tetroxide (N_2O_4)	Oxidizer	725	9,200
Liquid Oxygen (LOX)	Oxidizer	90,000	882,900
Hydrazine (UDMH)	Fuel	620	4,500
Liquid Hydrogen (LH2)	Fuel	128,200	76,900
LH2 & UDMH	Fuel	--	81,400

Table 3 provides a list of the propellants considered for use with this facility. RP-1 and LOX are the two main propellants used for the K-1 vehicle. This list has been expanded however to include Liquid Hydrogen, Hydrazine, and Nitrogen Tetroxide. As the other vehicle/user is not known, hence the propellants required are unknown, inclusion of these propellants provides a worst case storage and distribution scenario for the model. The volumes provided in the table above cover the upper limits of the various vehicles considered in the 1Mlb Thrust Evaluation of this study.

Modest quantities of Nitrogen Tetroxide and Hydrazine are included for planning purposes as another potential user or payload might require these commodities. Hydrogen quantities are based on the existing tanks at Cx 20. The quantities for all the above were determined using reasonable values for different rockets of the sizes being considered. The Quantity Distance (QD) for each propellant was determined using the amount present and type of hazard that the propellant represents.

To provide defined data for site design the QDs for the storage tanks are calculated based on the assumed quantities for storage. To better understand the quantity distance values, the following definitions are used to describe the nomenclature. Quantity Distance (QD) is the quantity of explosives material and distance separation relationships providing defined types of protection. These relationships are based on levels of risk considered acceptable for the stipulated exposures and are defined by the following distances. The Inhabited Building Distance (IBD) is the minimum allowable distance between an inhabited building and an explosive location. The Public Transportation Route Distance (PTRD) is the allowable distance between an explosive location and any public street, road (including any on an establishment of military reservation), highway, navigable stream, or passenger railroad that is routinely used for through traffic by the general public. The Intra-line Distance (ILD) is the distance to be maintained between any two operating buildings and sites within an operating line, of which one contains or is designed to contain explosives. The Inter-magazine Distance (IMD) is the minimum distance allowed between two explosives locations.

Quantity Distance Calculation Approach

The Quantity Distances for storage of the propellants was calculated using the approach provided in the DOD Ammunition and Explosives Safety Standard (DOD 6055.9) Ref [10]. The following tables provide details on how these values were estimated for each propellant type.

RP-1

For the fuel RP-1 the following rules apply for calculating the Quantity Distances.

Table 4: Quantity Distance Criteria for RP-1 Storage

RP-1 Storage Volume (gal)	ILD / IMD (ft)	IBD / PTRD (ft)
Up to 100,000	25	25
100,000 to 500,000	37.5	37.5
Over 500,000	50	50

Further information can be found on page 149 of DOD 6055.9 Ref [10]. For additional Reference, the required RP-1 for one K-1 launch is only 35,000 gallons.

Liquid Oxygen (LOX)

For Liquid Oxygen the following rules apply for calculating the Quantity Distance criteria for storage in detached buildings or tanks.

Table 5: Quantity Distance Criteria for LOX Storage

LOX Storage Mass (lbs)	ILD / IMD (ft)	IBD / PTRD (ft)
Unlimited	100	100

Further Information can be found on page 152 of DOD 6055.9 Ref [10].

Nitrogen Tetroxide (N2O4)

Nitrogen Tetroxide is considered an NFPS Class 2 Oxidizer and the following rules apply for calculating the Quantity Distance criteria for storage in detached buildings or tanks.

Table 6: Quantity Distance Criteria for N204 Storage

N2O4 Storage Mass (lbs)	ILD / IMD (ft)	IBD / PTRD (ft)
Up to 600,000	50	50

Further Information can be found on page 150 of DOD 6055.9 Ref [10]. For Reference, the Space Shuttle uses 20,000 lbs of N2O4.

Liquid Hydrogen (LH2) & Hydrazine (UDMH)

The methodology for calculating the QD criteria for liquid hydrogen is the same as that for calculating the QD criteria for bulk quantities of hydrazine. Additionally, if LH2 and UMMH are in a relative proximity to each other but maintaining Inter-Magazine, IMD, distances they can be treated as a single commodity and the total sum of their weights can be used to calculate a single QD.

Table 7: Quantity Distance Criteria for LH2 & UDMH Storage

Storage Weight (lbs)	ILD / IMD (ft)	IBD / PTRD (Protected) (ft)
W	0.375 * IBD	$-154.1 + 72.89*\ln(W) - 6.675*[\ln(W)]^2 + 0.369*[\ln(W)]^3$

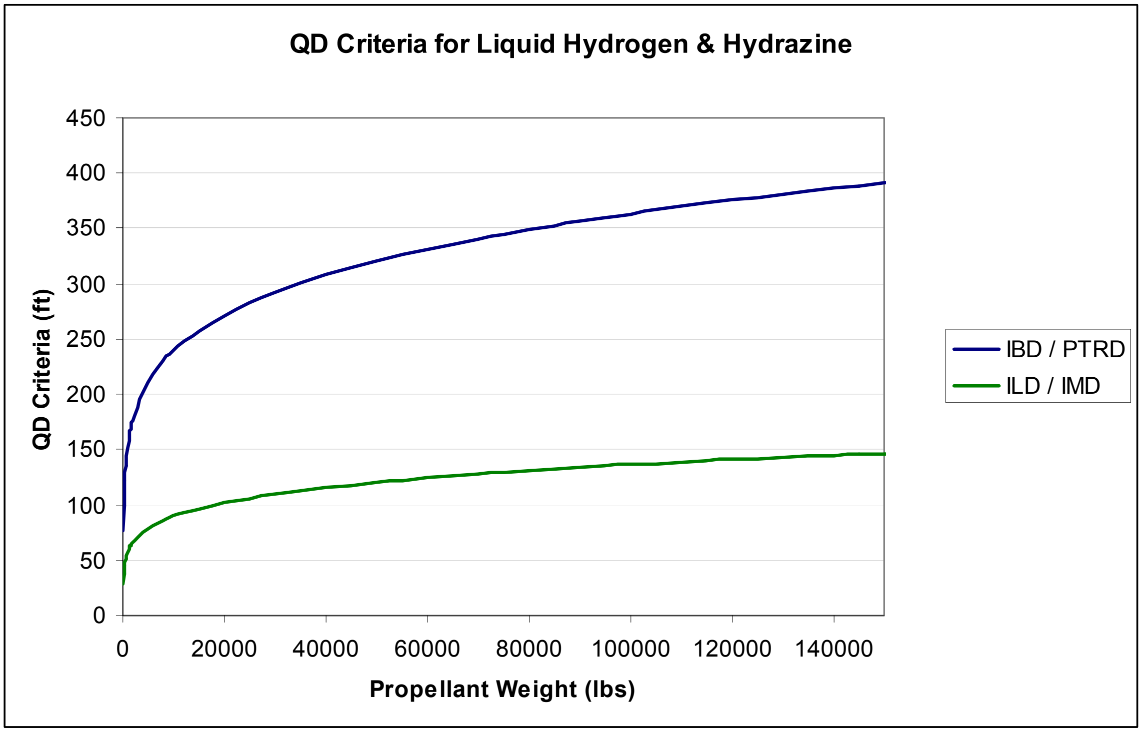


Figure 3: QD Criteria for Liquid Hydrogen and Hydrazine

The equation listed in Table 7 is valid for propellant weights greater than 100 lbs.

Quantity Distance Estimates for Storage of Propellants

The QDs required for individual stored commodities are relatively small when compared to the QDs required for an integrated, flight ready vehicle. Figure 4 shows the relative tank sizes and quantity distances for the various propellants. Located at the center is the relative size of the propellant tanks. The light yellow colored circle beyond the tank perimeter sweeps out the appropriate QD for the commodities quantities located in the tank. The bold black line defines the IBD and PTRD, while the orange line marks the bounds for the ILD and IMD. Note that the hydrogen and hydrazine tanks together form the only propellant storage area where the ILD/IMD is not the same as the IBD/PTRD.

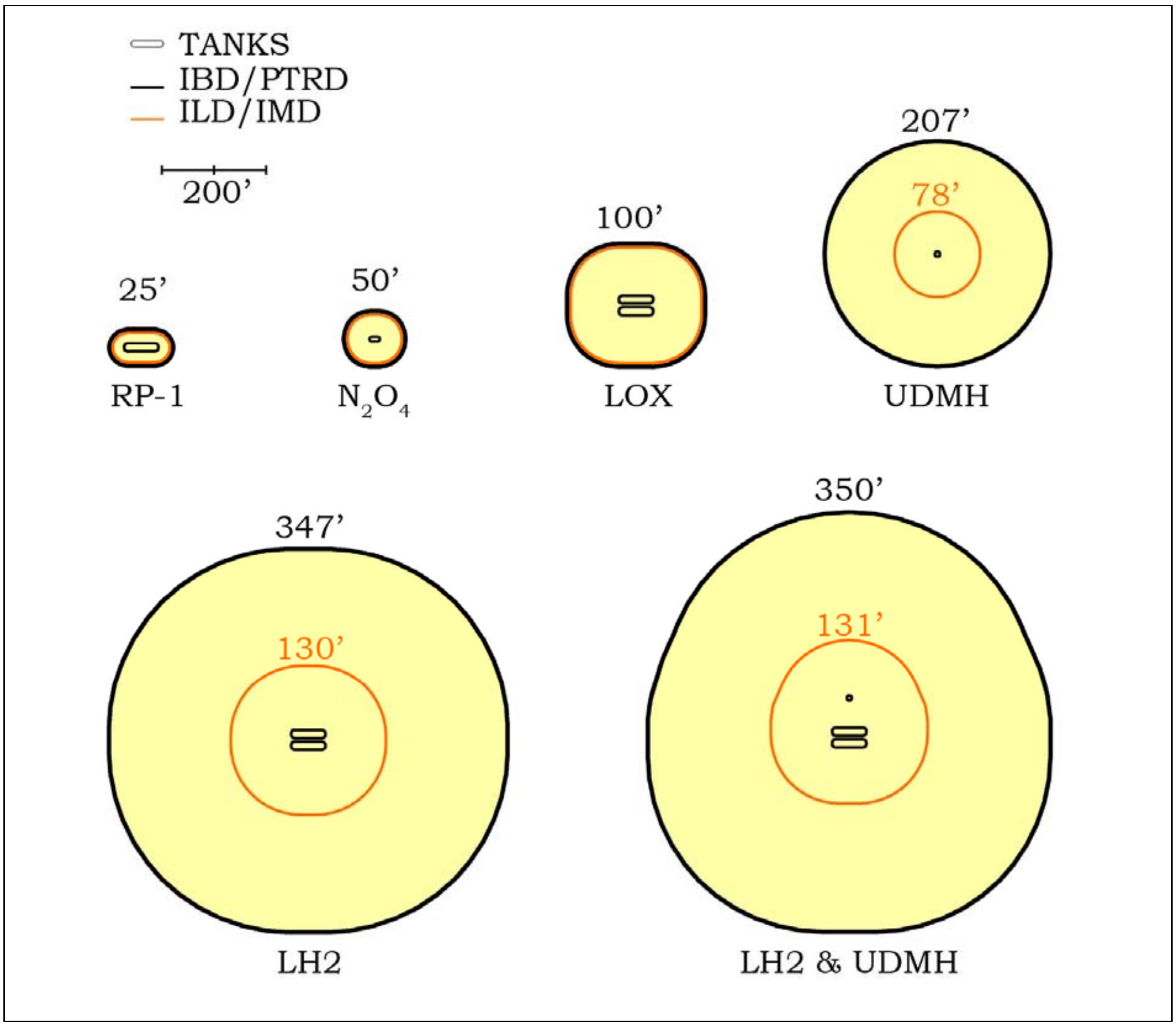


Figure 4: Quantity Distance Circles for Specific Propellants

The volumes and masses provided in Table 3 are used to calculate the QDs for storage of each of the propellants listed. Using the DOD Ammunition and Explosives Safety Standards (DOD 6055.9-STD) the Quantity Distances for storage of these propellants were estimated and are shown in Table 8.

Table 8: Quantity Distances for Storage of Various Propellants (1 Mlb Thrust Evaluation)

Propellant	**Type**	**ILD / IMD** (ft) Radius	**IBD / PTRD** (ft) Radius
RP-1	Fuel	25'	25'
Nitrogen Tetroxide (N_2O_4)	Oxidizer	50'	50'
Liquid Oxygen (LOX)	Oxidizer	100'	100'
Hydrazine (UDMH)	Fuel	78'	207'
Liquid Hydrogen (LH2)	Fuel	130'	347'
LH2 & UDMH combined	Fuel	131'	350'

QD Differences for Stored commodities between 1 Mlb Thrust and 2 Mlb Thrust Evaluations

For the 2 Mlb Thrust Evaluation the larger vehicles will undoubtedly have much larger volumes of propellants. It is important to ascertain what effect that this increase in storage will have on the QDs calculated for the storage of the Propellants. The volumes of propellants shown in Table 3 are arbitrarily increased to 180% of their original value and the QDs are recalculated. These comparisons are presented in the following two figures for both the IBD / PTRD and the ILD / IMD. An 80% increase in the volume of propellants has only an 11% increase in the QD for the LH2 and Hydrazine combination. Using larger class vehicles on the pad will not have a significant increase in the QDs for storage of the individual propellants.

Table 9: QD Comparison for Evaluations

	IBD / PTRD			ILD / IMD		
Propellant	1 Mlb Thrust Evaluation (ft)	2 Mlb Thrust Evaluation (ft)	% Increase	1 Mlb Thrust Evaluation (ft)	2 Mlb Thrust Evaluation (ft)	% Increase
RP-1	25	37.5	50%	25	37.5	50%
N2O4	50	50	0%	50	50	0%
LOX	100	100	0%	100	100	0%
UDMH	207	231	12%	78	87	12%
LH2	347	386	11%	130	145	12%
LH2 & UDMH	350	390	11%	131	146	11%

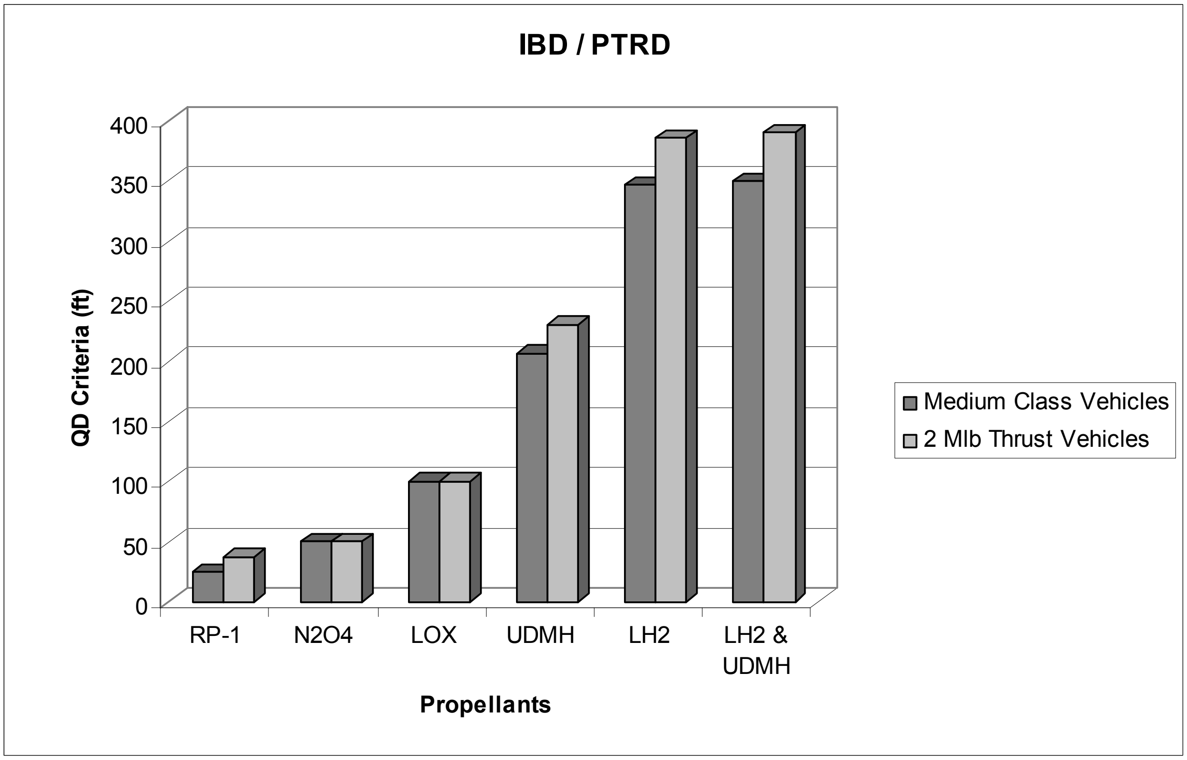


Figure 5: QD Comparison for IBD & PTRD

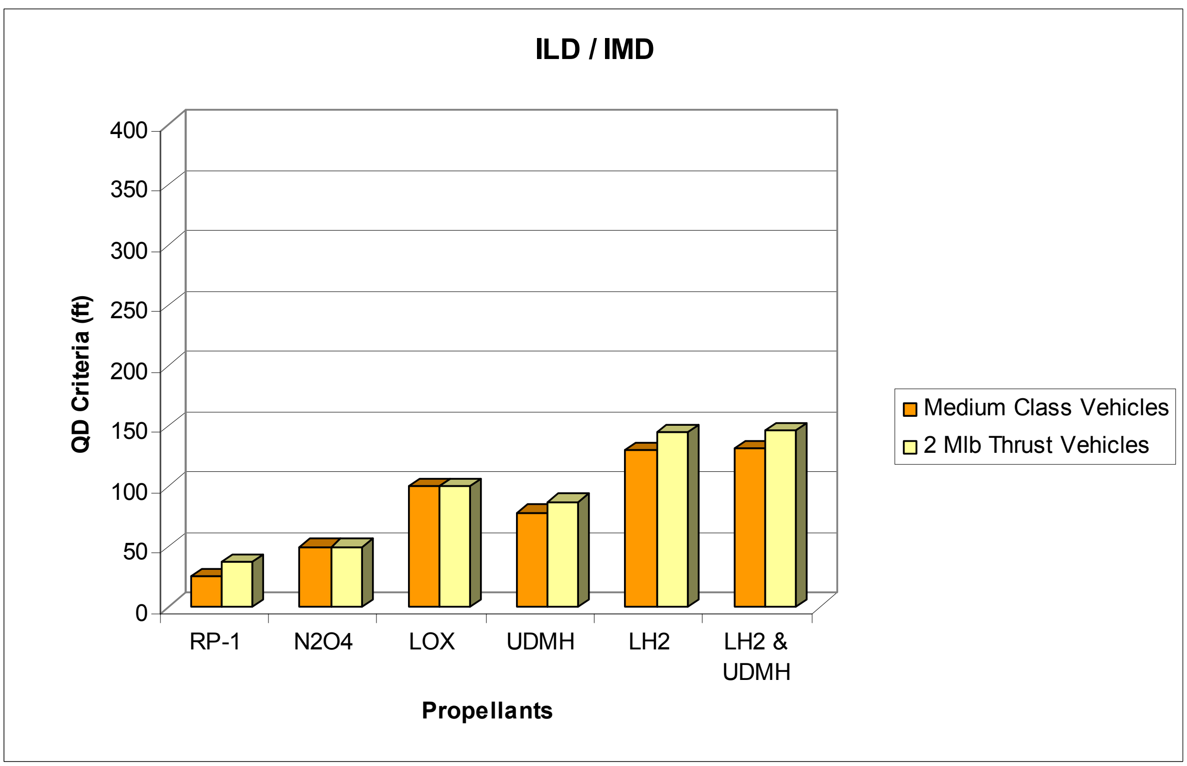


Figure 6: QD Comparisons for ILD & IMD

The above exercise in identifying QDs for commodity storage revealed that on a new site without the proximity of existing facilities and the ability to site components in a large area the storage QDs thus obtained need not be restrictive to overall site planning.

3.4 Conceptual Launch Facility Site Layout

Overall Launch Facility Site Plan

As the squibs and other separation components for the assumed user vehicles are unknown, the integrated vehicle QDs shown below are obtained by using the QDs extant for Atlas V and Delta IV. Both of these vehicles, in their 'heavy' configuration are in the 2 million pound plus range of vehicles.

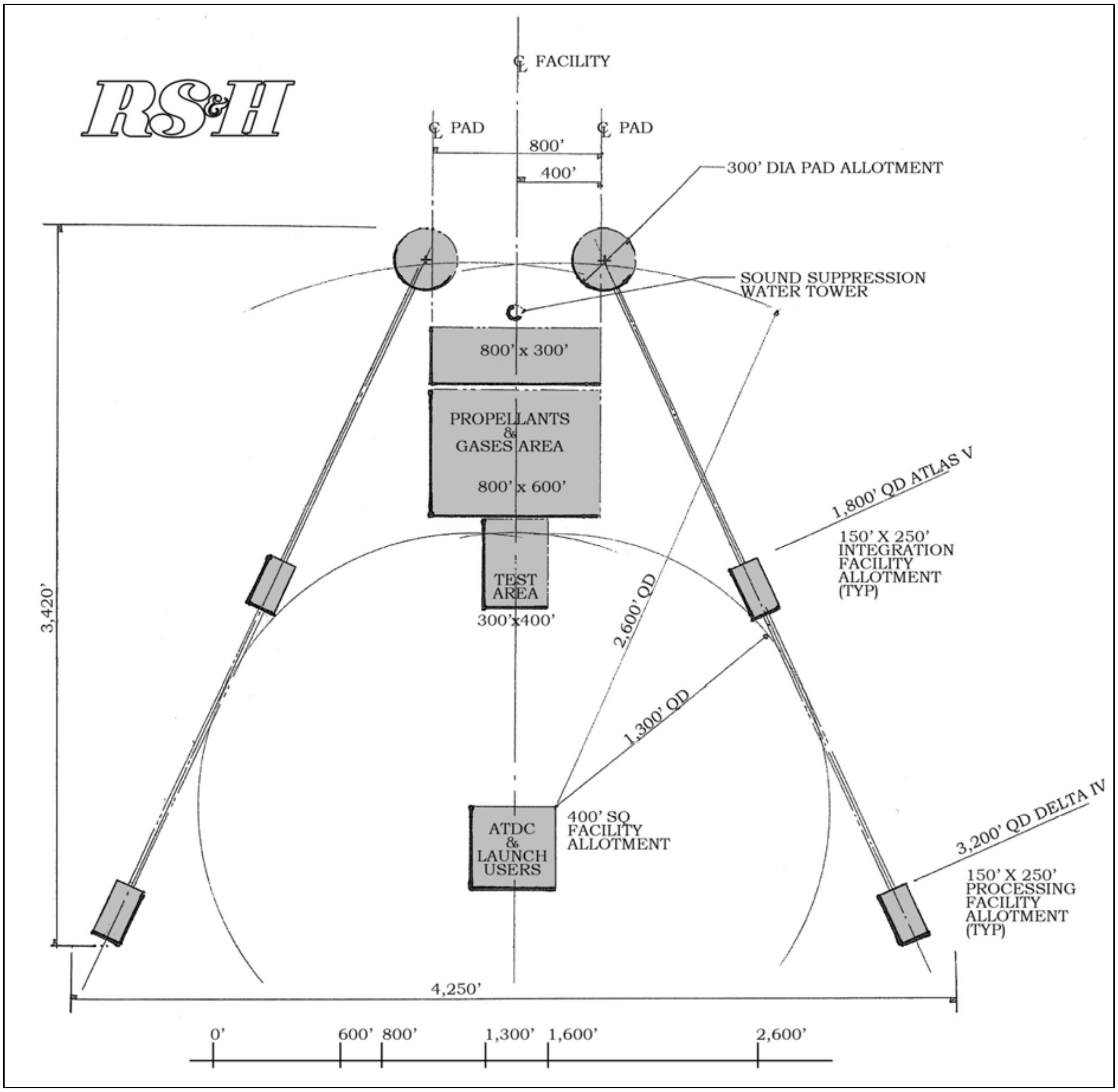


Figure 7: Symmetrical Vertical Launch Facility Site Layout

The plan shown above depicts a symmetrical layout of the required facilities based on storage, processing and integrated vehicle QDs. The QDs used for integrated vehicles are obtained from Atlas V and Delta IV data. The QDs for the propellant and commodity tanks were calculated from the estimated quantities of each. Distance between the integration facilities and inhabited buildings is based on the existing distance between the VAB and OSB-1 and was used to accommodate solid motor boosters should that be a requirement. This distance is very conservative for this study.

If the COTS award users are used as "Strawman" examples the physical dimensional differences between the two vehicles would make use of a single pad difficult. Therefore two pads are shown, one for each user. It may be possible that an interchangeable launch mount, changeable umbilicals and sound suppression/heat protection water piping might be designed to be reconfigured and checked out between coordinated flight intervals of the two users. However such is beyond the scope of this study, hence two individual, dedicated to one user, launch pads are shown.

Shared propellant and commodity storage is an assumed cost savings of the proposed model. Each user is expected to have separate commodities controls and protocols. Propellant and other piping is intended to be controlled from the supply area to each user's facilities as required and scheduled.

Also depicted are two options for flight vehicle integration. The integration facilities for each user are in a direct line back from the respective pads. Two options are shown in each case.

1. The closest structure is intended for integration of a single flight vehicle. At launch there are no flight components remaining within the integration facility. There are several models for such spacing. Integration facilities are known as Mobile Service Towers (MST) are only several hundred feet from the launch. The model for the distance shown above is the United Launch Alliance facilities at Cx-41, CCAFS where the distance from the non-mobile integration facility to the launch pad is 1,800 feet.
2. Another option exhibited above is the processing facility at 3,200 feet from the launch pad. At the time of launch there can indeed be other flight components stored or currently undergoing processing in the facility. The model for this is the United Launch Alliance facilities at Cx-37, CCAFS.

Both the 1,800 and 3,200 feet numbers are for vehicles in excess of two million pounds of thrust. They are used as examples in excess of what is required for vehicles being considered in this study.

The integration/processing facilities shown could be for either horizontal or vertical vehicle processing. It is understood that horizontal processing/integration would require a means of vertical erection either at the integration facility for vertical transport to the pad or horizontal transport to the pad with erection to vertical occurring at the pad. For the two user concept investigated in this study one user facility will be shown with a vertical integration facility at 1,800 feet from the pad and vertical transport to the pad on steel rails.

The other user concept shows a horizontal processing facility 3,200 feet from the pad with horizontal transport to the pad on steel rails. Erection to vertical will occur at the pad similar to the United Launch Alliance facilities at Cx-37, CCAFS. This is also the RpK concept for the “strawman” user in this study.

Operations and Facilities

There appears to be no precedent for two competing, commercial launch providers with liquid fueled vehicles simultaneously sharing the same launch facility. Space Florida’s Cx-46 is a multi-user concept but all vehicles launched from there are, at the time of this writing, smaller, solid fueled vehicles with a low launch rate and require no liquid based commodities ground infrastructure.

As envisioned for the KSC Two-user Vertical Launch Pad, there will likely be a full-time resident operations crew that refurbishes after launch, manages the commodities and their infrastructure and generally maintains the entire facility. This assemblage of personnel will have as their main office an Administration Building and use a Maintenance Building for touch labor.

A greatly simplified conceptual commodities flow diagram is shown in Table 10. The dashed line represents a control signal that passes through the Area Control in the Administration building. In any given launch procedure for either user, the Area Control cedes flow decisions to the user group launching a vehicle.

Each user group is allotted one of the opposite wings of the Administration Building for administrative and other use during the integration and pre-launch process.

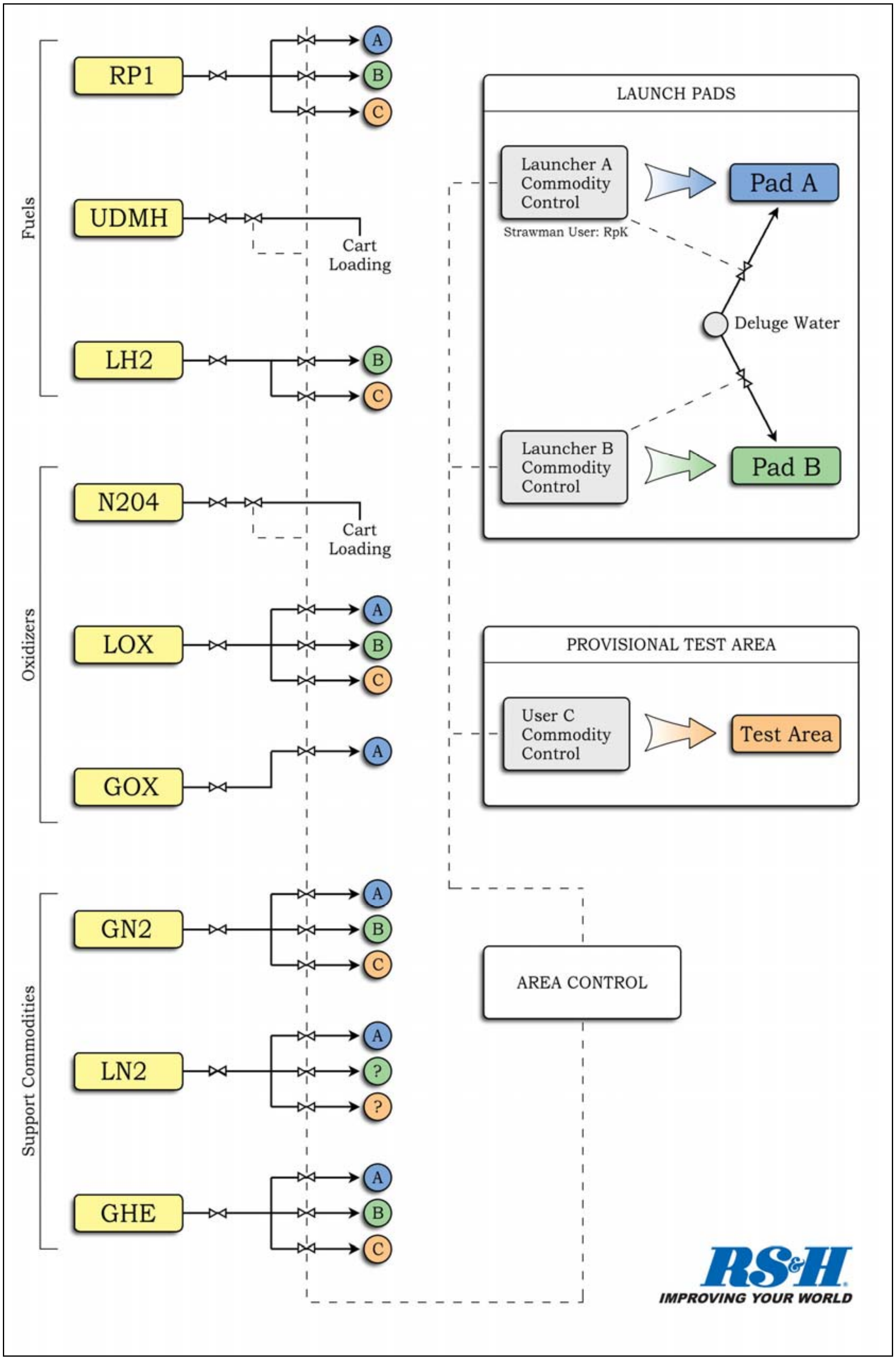


Figure 8: Shared Commodities Flow Diagram

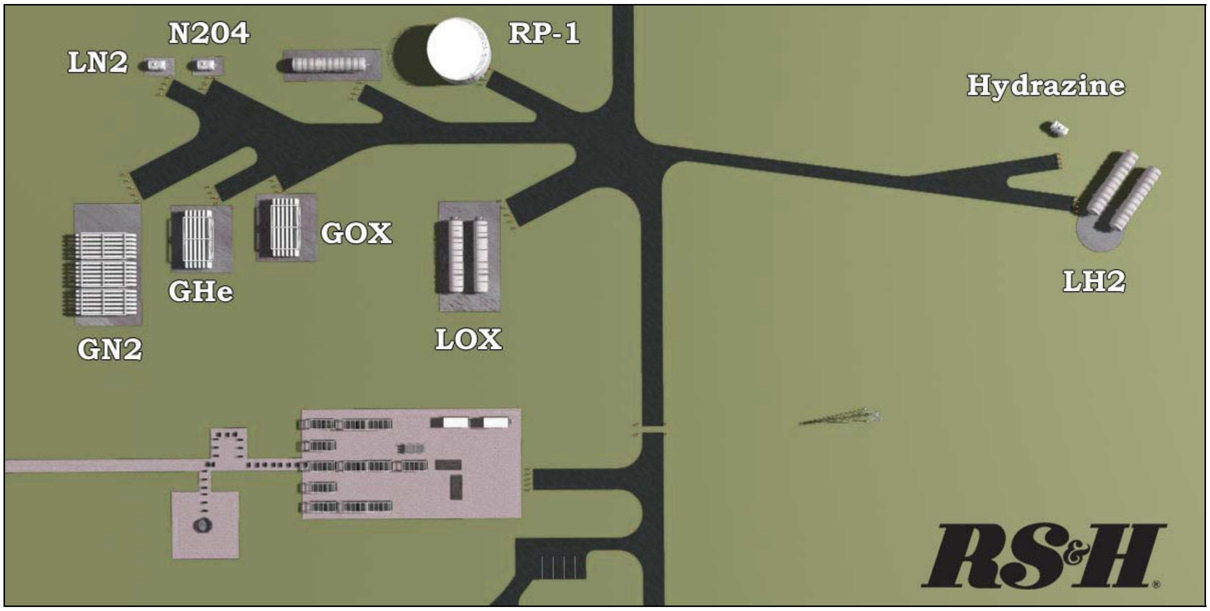


Figure 9: Possible Layout of Propellant Tanks

The plan view above depicts a possible layout of the propellant tanks. The tanks delineated are loosely based on the reuse of the ATDC tanks currently located at Cx-20. Cost estimates included in Section 8 are for obtaining new tanks. The distances between dissimilar propellant tanks and the distances between those tanks and other infrastructure must equal or exceed the minimum required distances shown in Figure 4. Often requirements for loading and maintenance access exceed the separation requirements based on individual tank QDs. Except for the LH2 and Hydrazine tanks this is the case for the above plan.

Administration Facility

A common administration and control facility is located near the center between processing facilities and the commodity tank farm. Adjacent to each side of the common facility is a user specific space for offices and other ancillary functions including dedicated facilities for communication, conference rooms etc. Restrooms and support facilities are anticipated to be in the common core. The middle section is anticipated to be occupied by the facility administration and operations staff. The area control functions also reside in this central structure.

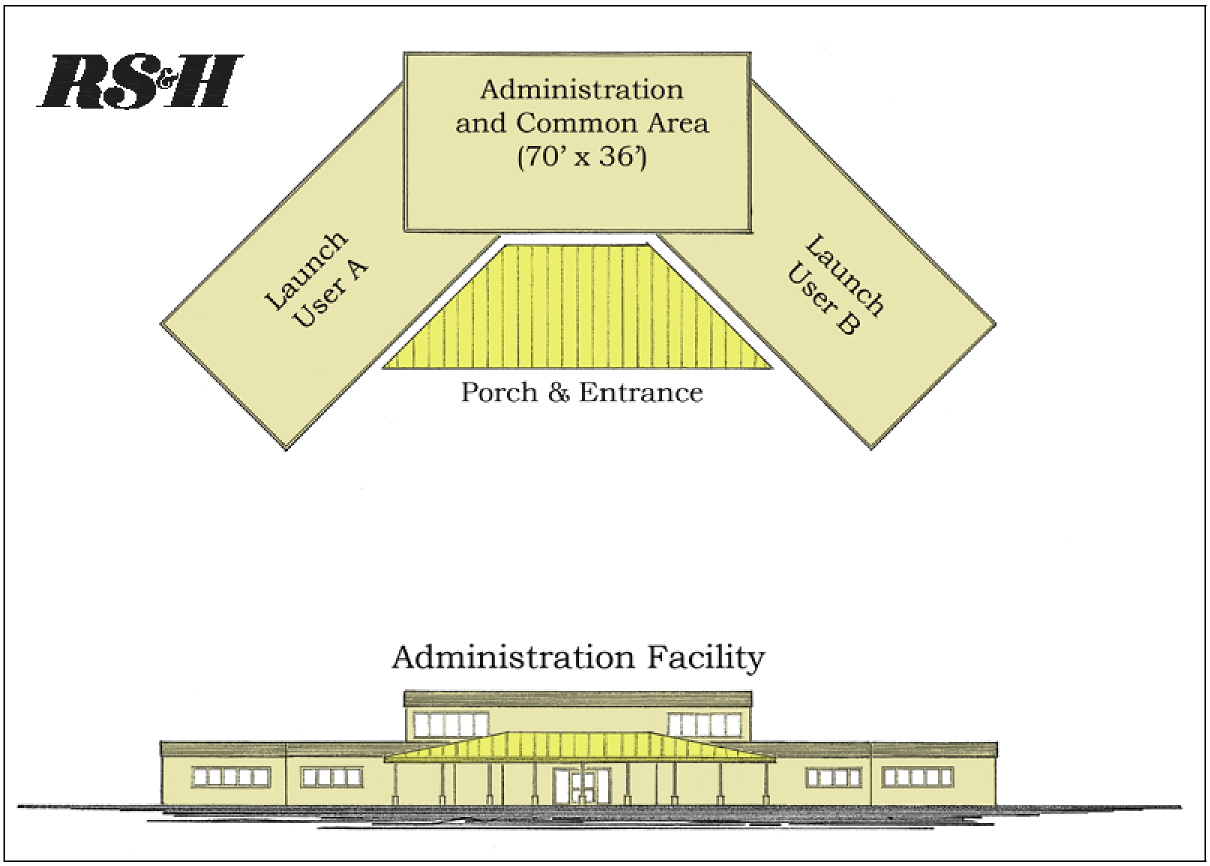


Figure 10: Common Maintenance/Administration & Control Facility

Construction of the facility is anticipated to be incremental. The core, by itself and/or perhaps with launch user A, is constructed first. The additional wing for launch user B could be constructed at a later time with little disruption to other activities in the extant building.

Flame Deflector

Determining the required flame deflector height is the first step in development of a launch pad as it can provide a basis for other design components such as pad elevation and launch vehicle transportation slopes. For this study NASA Flame Deflector Standard (KSC-STD-Z-0012B) was used to estimate the flame deflector heights for the list of launch vehicles shown in Table 10. It is important to note that the flame deflector estimates below are approximate and other variables can affect their design. The flame deflector heights listed in the following table provide an appropriate range for deflector heights at this level of study.

Table 10: Estimated Flame Deflector Heights Required

Launch Vehicle	Estimated Flame Deflector Height Required ft
Athena II	16
Atlas IIAS	*
Atlas IIIB	32
Atlas V 400	32
Atlas V 500	*
Atlas V Heavy	32
Delta II	*
Delta III	*
Delta IV Medium	29
Delta IV Medium Plus	*
Delta IV Heavy	29
K-1	24
Commercial Taurus	18
Falcon I	9
Falcon 9[1]	26
Falcon 9 Heavy[1]	25
* No height calculated for vehicles with SRBs	

Based on the results above, a pad height of 30 feet in height above grade will be used for the basis of this study. Such height can accommodate all vehicles shown in the above chart. Figure 11 shows relative flame deflector heights for the K-1 launch vehicle and Falcon 9 Heavy launch vehicle. These deflector heights are compared to the default deflector design for use in this study. The default deflector is estimated have a height of 25ft and has a 60 degree slope. For additional comparison a flame deflector for the Crew Launch Vehicle (CLV) used for the Constellation Program is shown as well.

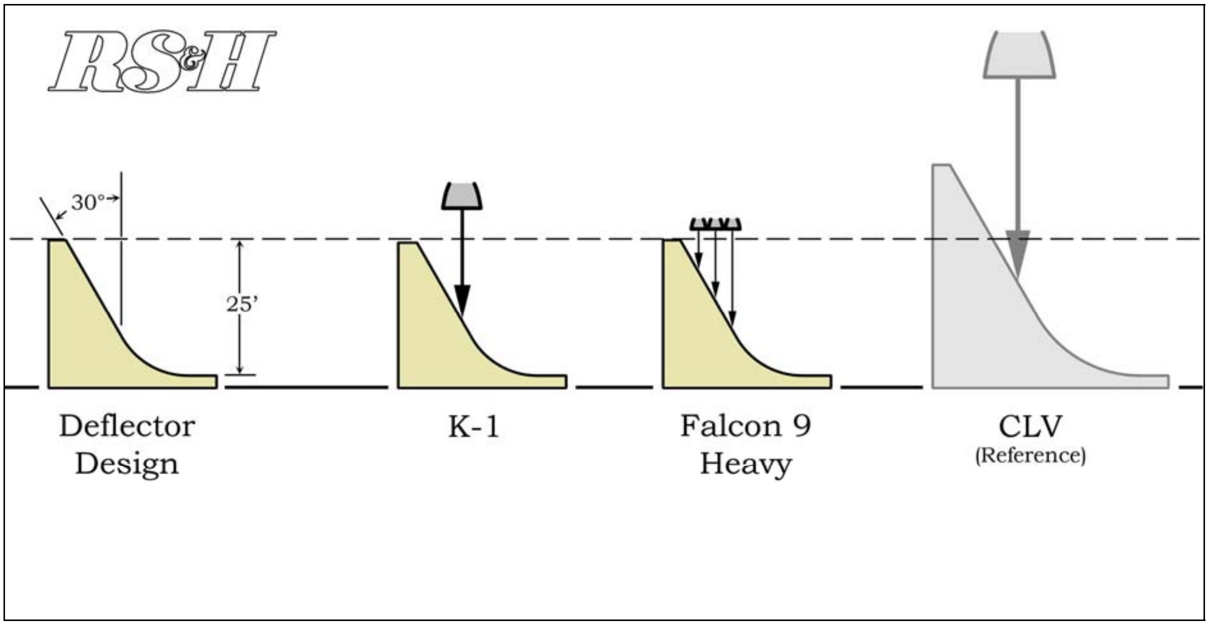


Figure 11: Flame Deflector Design per KSC-STD-Z-0012B

Pad Elevation Options

Several options are readily available for configuring the elevations of the facility. To develop these options, the first step is to determine the placement of the flame deflector. The flame deflector can either be completely above grade, partially below grade, or completely below grade. It is desirable to keep the flame deflector completely above grade as it prevents water from pooling at the base of the flame deflector. The water, if deep enough, must be eliminated prior to launch. The next item to consider in the design sequence is the orientation of the transportation route. The transportation route from the integration building to the pad can be either horizontal or sloped depending on the relative elevation of the integration building to the flame deflector elevation. Keeping the transportation route horizontal reduces potential vehicle roll-out complexities when moving up a slope or navigating vertical curves.

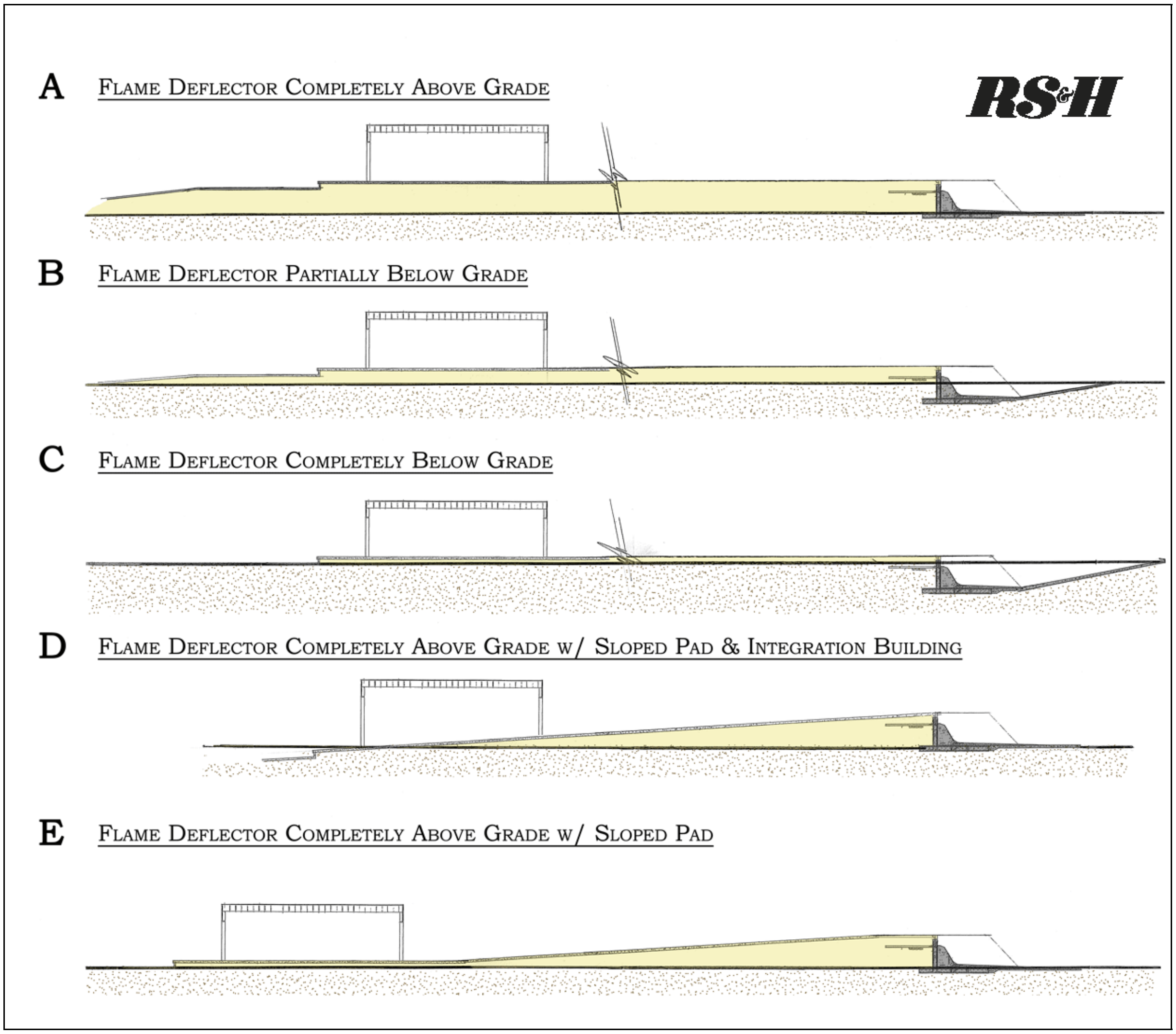


Figure 12: Possible Pad Elevations

The final step is to position the integration building. The integration building can be either at the same elevation as the pad or at a different elevation. Placing the integration building at a different elevation requires a sloped transportation route. The optimal transportation solution is to have the integration building at an elevation that permits a flat route to the pad.

Pad Elevation Option A

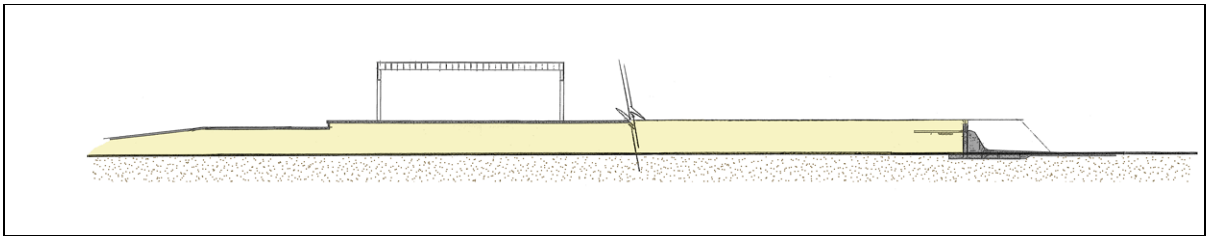


Figure 13: Pad Elevation Option A

In Option A, shown above, the flame deflector is completely above grade and the integration building is elevated to provide a flat horizontal transportation route. Having the flame deflector completely above grade prevents water accumulation in the flame trench. This option requires the largest amount of fill due to the elevated integration building and the fill required to maintain that elevation all the way to the pad.

Pad Elevation Option B

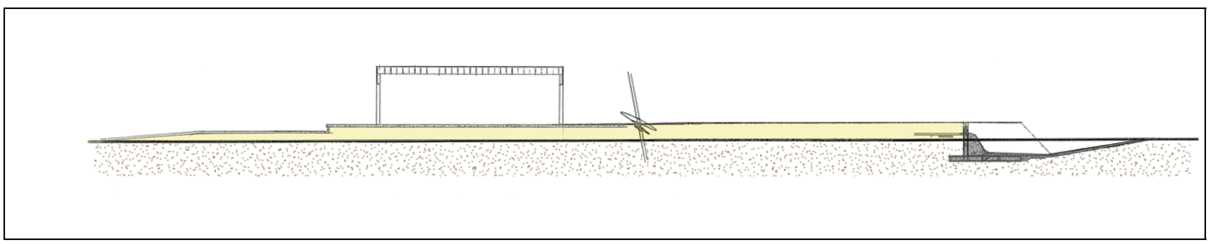


Figure 14: Pad Elevation Option B

In Option B, above, the flame deflector is partially below grade and the integration building is elevated to provide a flat horizontal transportation route. Having some of the flame deflector and flame trench below grade allows for water to accumulate at the bottom. In this option water pumps are required as critical GSE components to ensure that that flame trench is dry prior to a launch. Less fill is required for this option compared to Option A.

Pad Elevation Option C

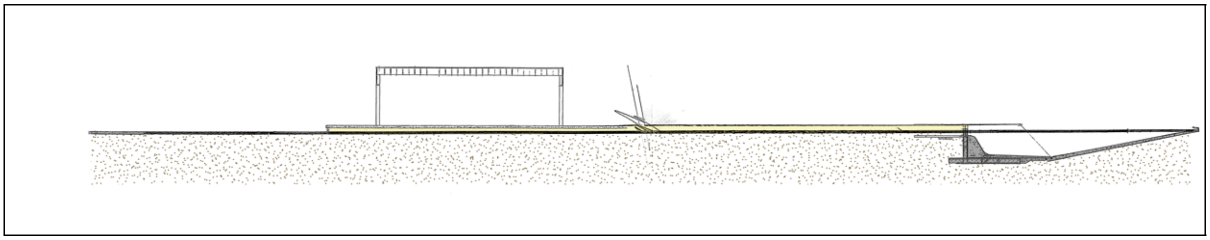


Figure 15: Pad Elevation Option C

In Option C, shown above, the flame deflector is completely below grade and the integration building is elevated to provide a flat horizontal transportation route. Having the entire flame deflector and flame trench below grade creates a deep basin that allows for water to accumulate at the bottom. In this option water pumps are required as critical GSE components to ensure that that flame trench is dry prior to a launch. This option requires the least amount of fill to be used.

Pad Elevation Option D

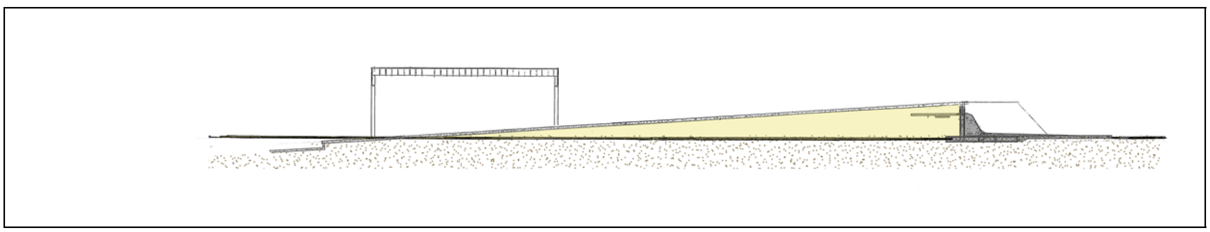


Figure 16: Pad Elevation Option D

In Option D, shown above, the flame deflector is completely above grade and the integration building is near grade level. To provide a flat, but not horizontal, transportation route the pad slope and integration facility floor are required to be the same angle at different elevations. Having the flame deflector completely above grade prevents water accumulation in the flame trench. This option requires less than half the amount of fill required for Option A as “A” also requires a ramp from grade to the integration facility elevation. The distance from the integration facility to the pad along with the flame deflector height determines the slope required.

This option is included because the “straw-man” user, the RpK K-1 vehicle operational scenario cannot tolerate vertical curves once the vehicle is integrated. This option uses less fill than Option A but more fill than Option E below. The limiting factor appears to be the amount of slope tolerable in the integration facility floor. With 3,200 feet between the facility and a pad of 30 feet in height, the slope on the integration facility floor is 1 inch in 8.8 feet. This is deemed acceptable and will be used in this study as the default configuration for a processing facility where additional flight hardware resides in the facility at launch. A flame deflector thirty feet in height allows the bottom of the deflector to be five feet above surrounding grade.

Pad Elevation Option E

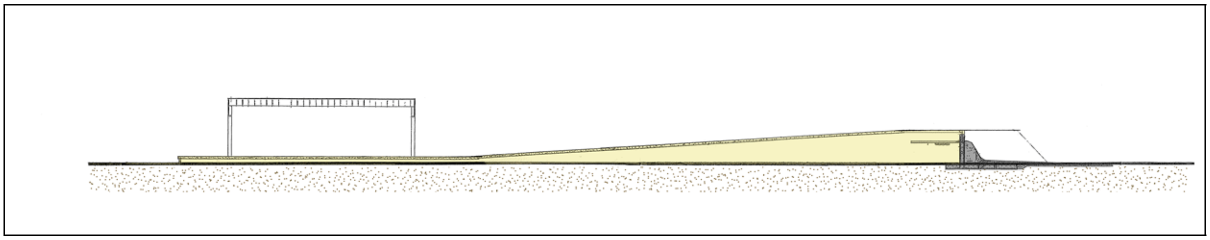


Figure 17: Pad Elevation Option E

In Option E the flame deflector is raised totally above grade but the integration facility is kept at grade. This scheme is similar to that seen at Cx 41, the Atlas V pad, and at Pads 39 A and B, the current Shuttle pads. Both vehicles are transported to the pad in a vertical configuration. The slope at Cx41 is barely perceptible and does not require a leveling capability on the transporter as is required on the Space Shuttle's Crawler/Transporter.

Horizontal Integration Facility

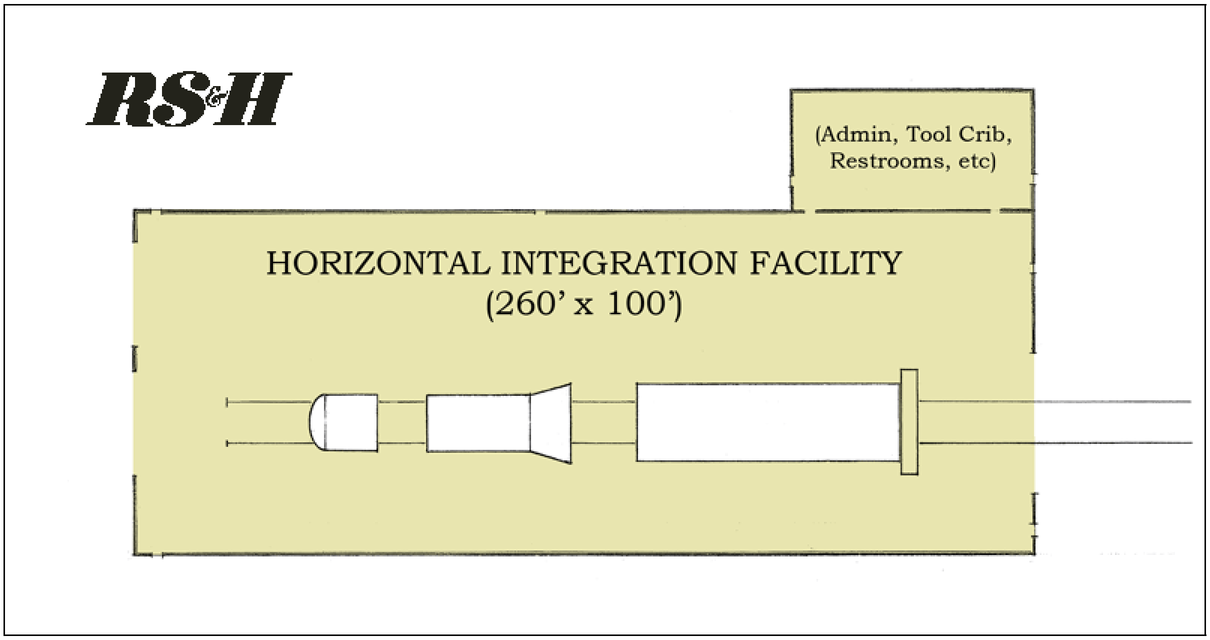


Figure 18: Horizontal Integration Facility Plan

The horizontal Vehicle Integration Facility (VIF) is designed to receive flight components from a remote processing facility (facilities) prepared for integration into a flight ready vehicle. The facility allows for weather protection and ventilation but does not afford conditioned air for the vehicle space or a clean room for payload/cargo access. It is anticipated that the Vehicle Integration Facility will provide a 15 tons capacity overhead crane for use in the high bay of the building. A low annex to the building provides for restrooms, administrative duties, security, tool crib, meeting rooms etc. Based on specific vehicle data the VIF can likely be closer to the launch vehicle than the Atlas V based 1,800 feet used in this study.

Horizontal Processing Facility

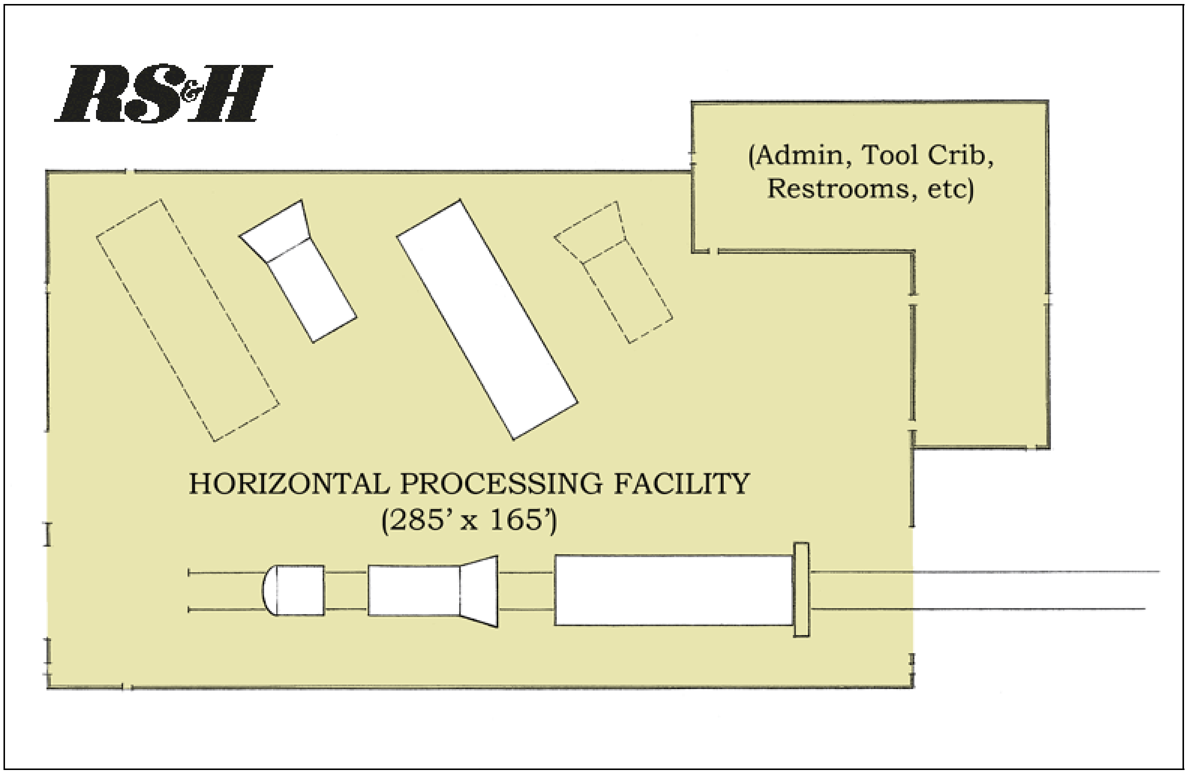


Figure 19: Horizontal Processing Facility Plan

The horizontal Vehicle Processing Facility (VPF) is designed to receive flight components from a remote manufacturing facility (facilities) and reusable components returned from flight. The building supports preparation of components for integration into a flight ready vehicle. The facility allows for weather protection and ventilation but does not afford conditioned air for the vehicle space or a clean room for payload/cargo access. It is anticipated that the Vehicle Processing Facility will provide a 15 tons capacity overhead crane for use in the high bay of the building. A low annex to the building provides for restrooms, administrative duties, security, tool crib, meeting room etc. Extra flight components undergoing either active preparation or storage are anticipated to be within the building at launch. Based on anticipated integrated vehicle QDs equal to or less than those for the Delta IV, the horizontal VIF can be as close as, or potentially closer, than 3,200 feet from the launch vehicle at launch used in this study.

Vertical Integration Facility

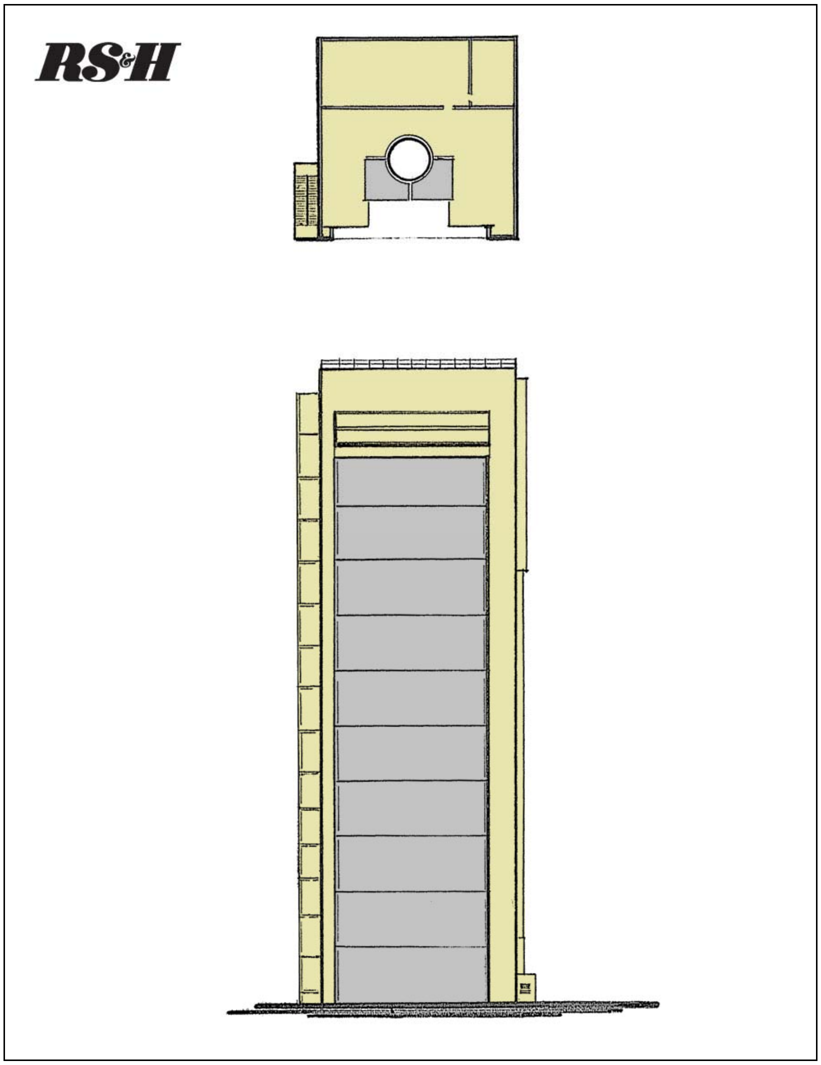


Figure 20: Vertical Integration Facility

The vertical Vehicle Integration Facility (VIF) is designed to receive flight components from a remote processing facility (facilities) prepared for integration into a flight ready vehicle. The facility allows for weather protection and ventilation but does not afford conditioned air for the vehicle space or a clean room for payload/cargo access. It is anticipated that the Vehicle Integration Facility will provide a 35 tons capacity overhead crane for use in the assembly bay of the building. A low annex to the building provides for restrooms, administrative duties, security, tool crib, meeting room etc. Based on anticipated integrated vehicle QDs equal to or less than those for the Atlas V the VIF can be equal to or less than 1,800 feet from the launch vehicle at launch used in this study.

General and GSE Maintenance Facility

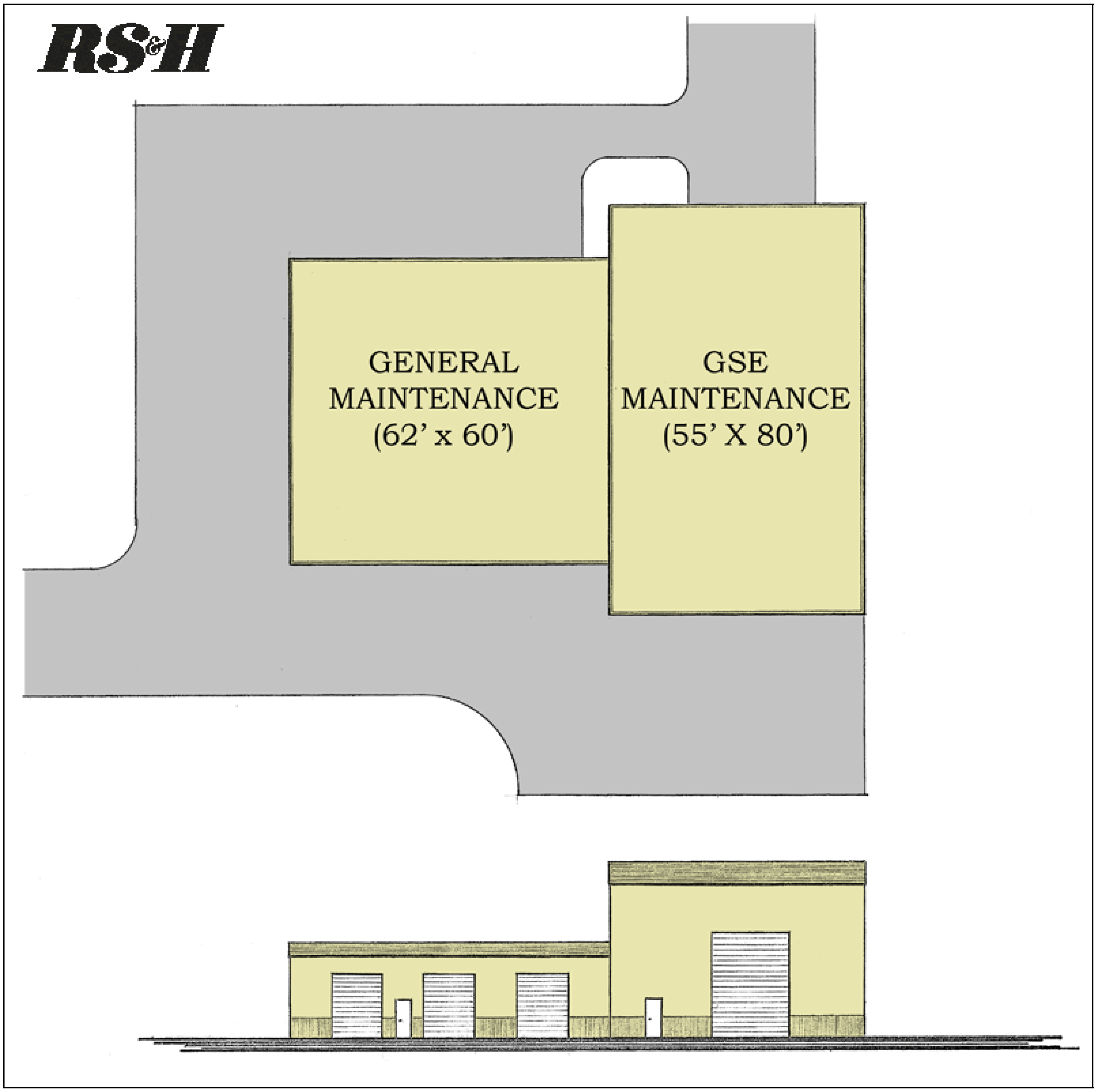


Figure 21: Common Maintenance Facility

Another building required for the facility will be a common maintenance facility for common user shipping, receiving and both GSE and general maintenance. A standard loading dock will be part of the general maintenance area. For the GSE maintenance a 15 tons capacity overhead crane is assumed. Facilities for cleaning valves and pipe spool pieces to required levels and certification for each commodity used will also be required.

Section IV: Definition of the Vertical Launch Site Limits

This section identifies the KSC legal boundaries and discusses areas of concern when considering sites locating on KSC property. Along with potential interferences with the Constellation Program, there are several areas of concerns. These are areas of environmental concerns, areas of historical or cultural value, and areas reserved for other uses. By identifying locations with possible issues, it will aid in narrowing down the possible locations on KSC property to ideal locations for new launch sites.

4.1 KSC Legal Boundaries

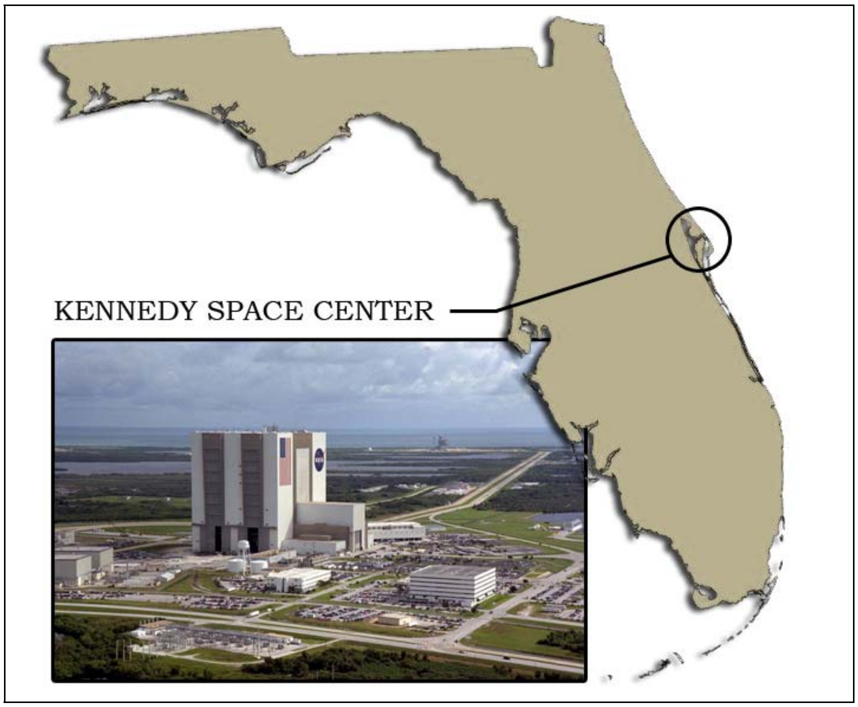


Figure 22: Kennedy Space Center Vicinity

Kennedy Space Center is located along the coast near Cape Canaveral, Florida. The legal boundaries of Kennedy Space Center are shown in Figure 23. Kennedy Space Center property extends as far south as Canaveral Barge Canal and as far north as the southern part of Volusia County. Portions of Kennedy Space Center are administered by Canaveral National Seashore and/or Merritt Island National Wildlife Refuge shown in Figure 24.

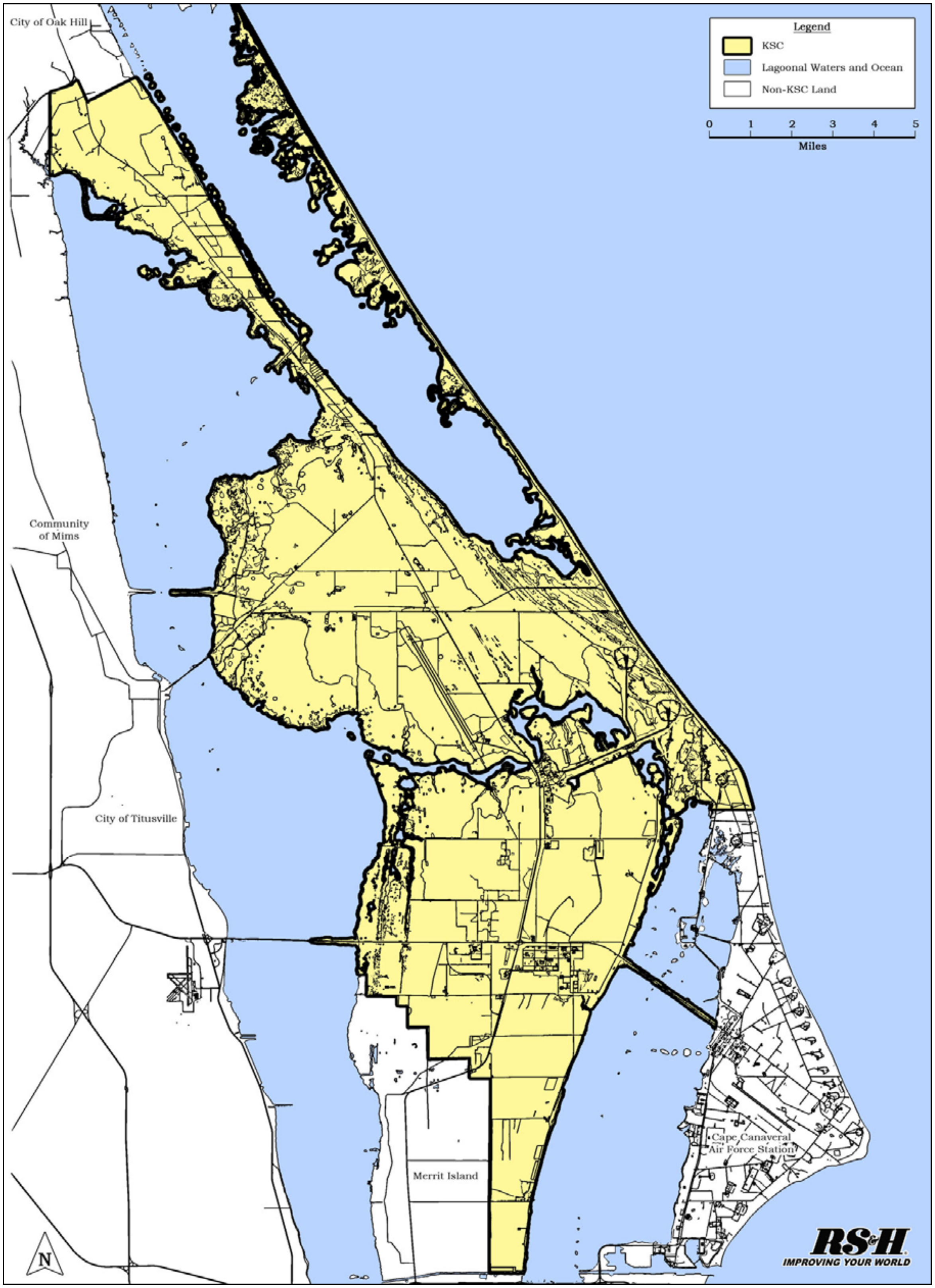


Figure 23: KSC Legal Boundaries

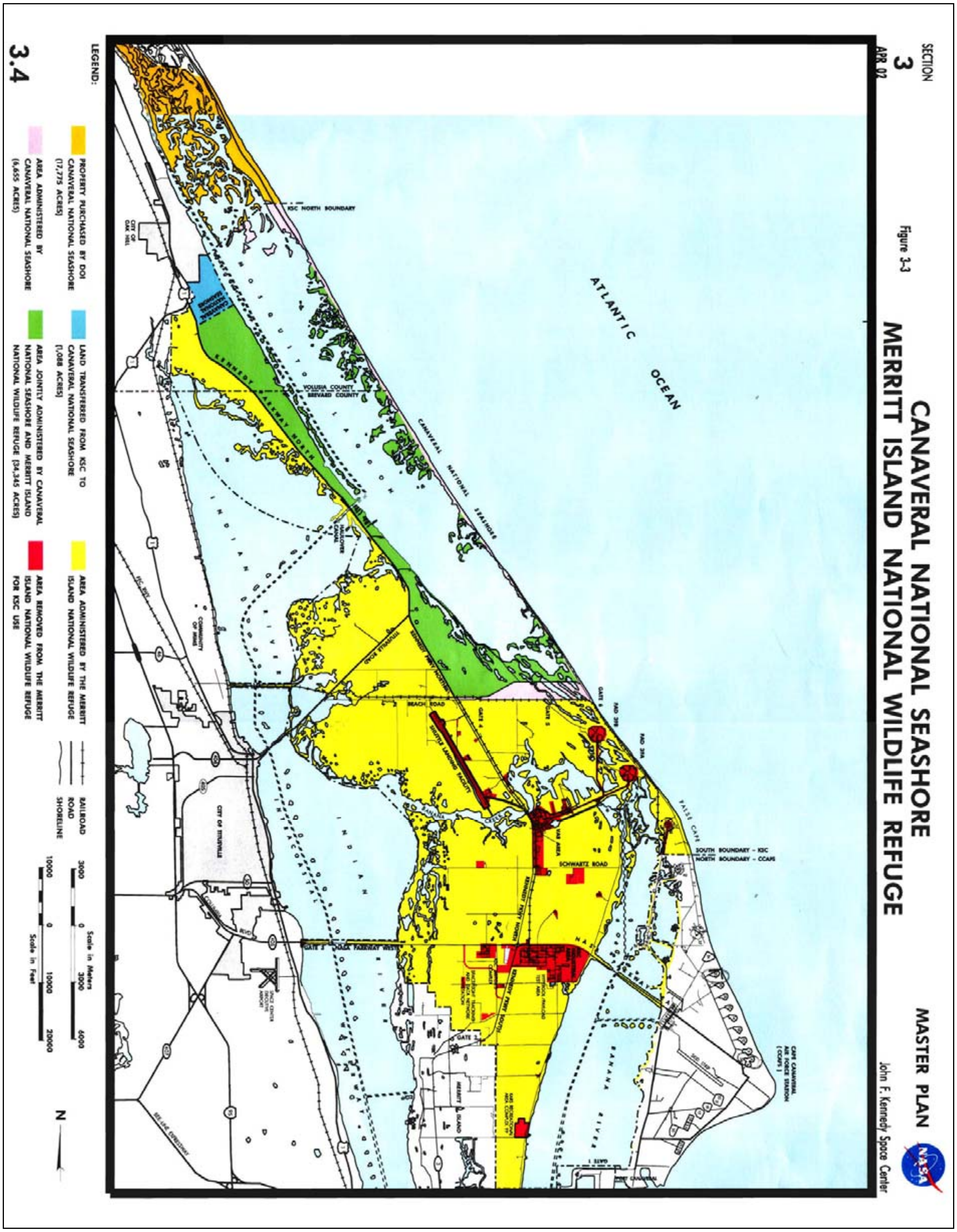


Figure 24: KSC Master Plan Property Administration Areas

4.2 Interferences with Constellation Program

Discussion with NASA Constellation personnel indicated that no major interferences with the proposed Constellation Program appear likely. Transportation of flight components and cargo/payloads could result in interference with similar transportation for the Constellation Program. This could easily be mitigated through communication and appropriate scheduling. Launch window overlaps likewise can be and are avoided through the 45th Space Wing Range scheduling.

4.3 Areas of Environmental Concern

Whenever considering construction on KSC property it is critical to take into account potential environmental concerns and what impact new site development has on the environment. In many instances this impact on the environment can be mitigated; however there is typically an effect on the cost and schedule. Wetland, Flora, Fauna, and Pollution/Contamination are all factors that need to be considered when developing a new site.

Discussions held with NASA KSC environmental personnel helped outline and verify the following brief discussion. Before development of a new site can take place, both an Environmental Baseline Survey (EBS) and an Environmental Impact Statement (EIS) must be completed. The EBS can take up to 3 months to complete with the goal of developing a baseline of the environment at the site. The EIS can take up to 18 months and cost up to $500,000. Depending on the outcome of the EIS, environmental mitigation may have to be completed. The EIS and EBS can be performed concurrently.

Wetlands

Wetlands are prevalent throughout the KSC property and are an important environmental asset to Florida. Wetland mitigation can be accomplished with restoration, enhancement or creation. For every 1 acre of wetland converted or lost, at least 10 acres of wetlands must be restored, enhanced or created. This method of preservation is important to minimize the environmental impact of new construction.

Fauna

The wildlife found on KSC property is extraordinarily diverse and more than 20 species are identified as either endangered or threatened on both state and federal lists. While only a few species are included in this discussion, it is important to understand that more species than those mentioned are affected by development on KSC property.

Figure 25 shows the known active bald eagles nests as of February 2006 on KSC property. On June 28, 2007 the bald eagle was removed from the endangered species list and reclassified as a threatened species. Although the species has been reclassified avoiding disturbance to their habitat is recommended.

Figure 26 shows the known primary scrub jay habitat as of October 1992. While this information is nearly 15 years old, the types of habitats that scrub jays reside in have not changed significantly in that time. During discussions with KSC personnel it was mentioned that the region around Area A, see Figure 38 between Cx-41 and Cx-39, is considered to be among the best Scrub Jay habitats on the combined KSC/CCAFS property.

Pollution/Contamination

As a result of the types of hazardous materials used in the space industry it is not uncommon to find polluted groundwater or contaminated soils at or around existing launch areas. Soil contamination is typically contained within the boundaries of most launch complexes. Since this study is looking at land outside the fence of existing complexes it is unlikely that soil contamination will be found, although soil testing is recommended. Groundwater contamination is a distinct possibility and can extend beyond the borders of existing adjacent pads. An Environmental Impact Statement and Environmental Baseline Survey are required.

When evaluating the area north of LC-41, the environmental Statement of Basis for Launch Complex 41 (Ref [18]) was reviewed. While launch complex 41 does have some levels of soil contamination, the groundwater contaminants did not exceed maximum contaminant levels established by the Environmental Protection Agency.

Data gathered on groundwater contamination for LC-39B shows a groundwater contamination plume on the northwest corner of the launch pad that extends slightly beyond the boundary of the perimeter fence. The groundwater contamination may be of concern in this area for new sites developed north of LC-39B. While no data was gathered on groundwater contamination for LC-39A, the activities conducted on both LC-39A and LC-39B in the past are similar enough that groundwater contamination may be present.

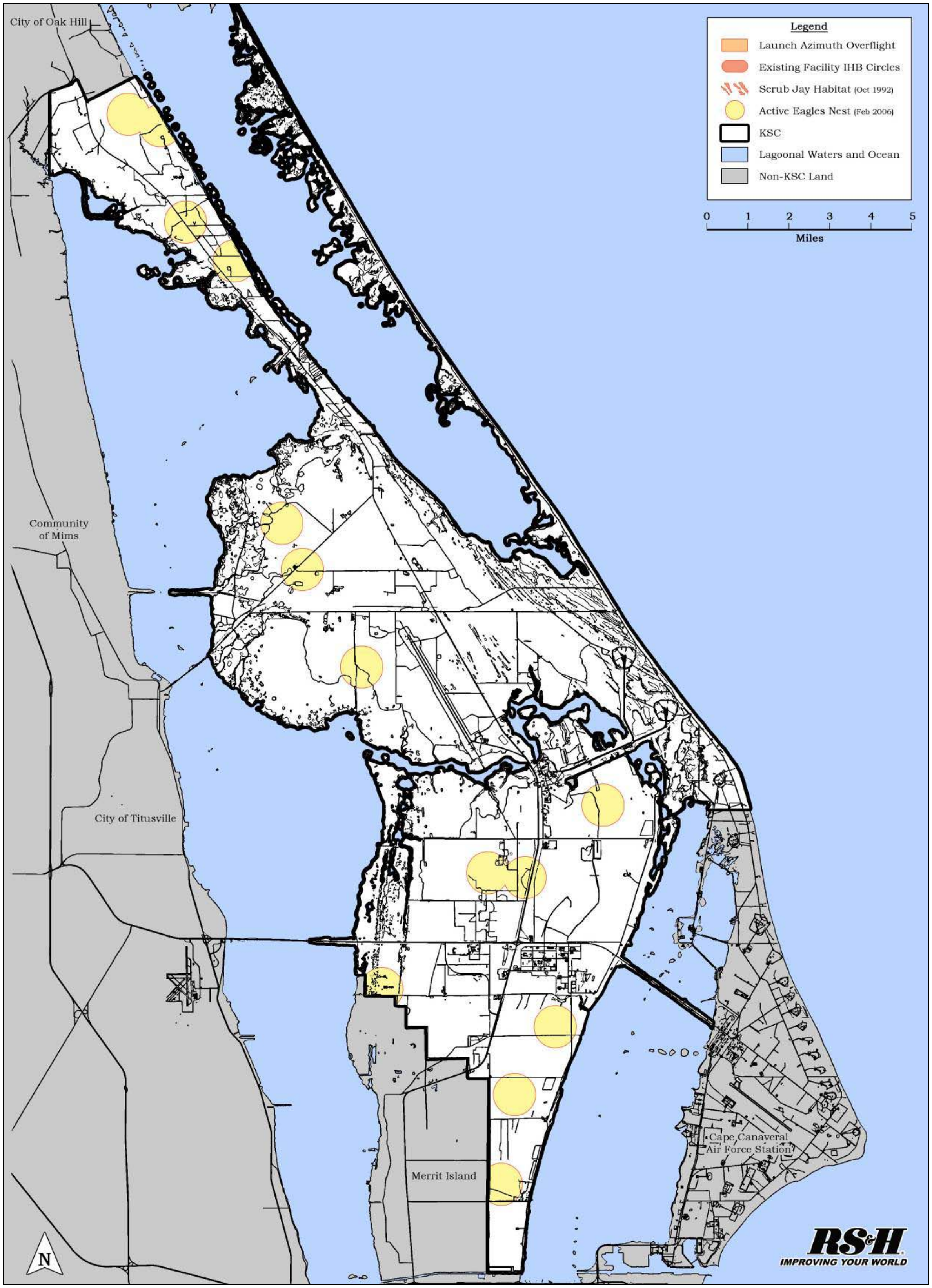


Figure 25: Active Bald Eagles Nests (Feb 2006)

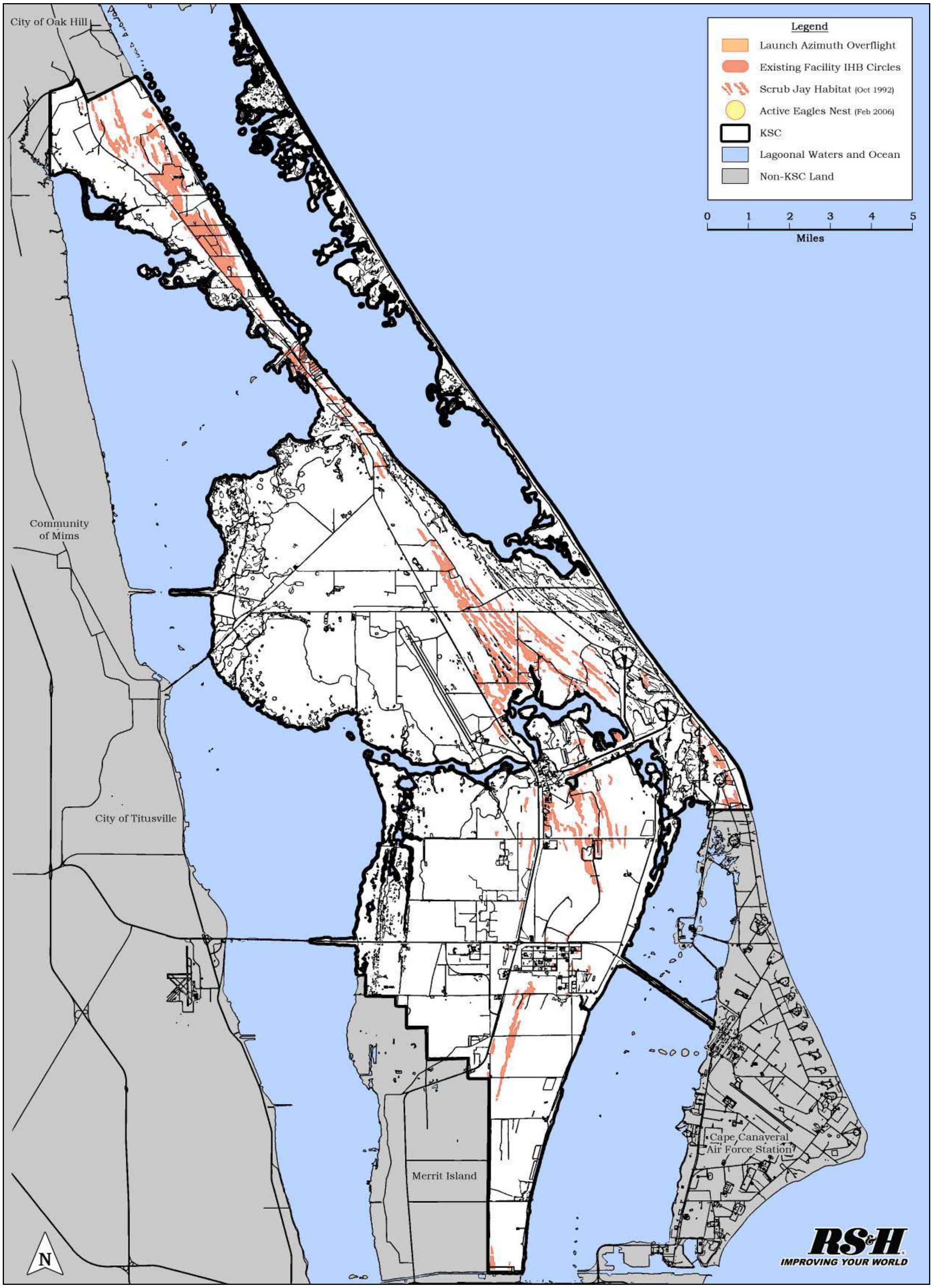


Figure 26: Scrub Jay Habitat (Oct 1992)

4.4 Areas of High Historical or Cultural Value

Cultural and Historical resources are scattered throughout KSC property. It is a priority to preserve these cultural and historic resources, therefore it is advantageous to find a site with a low impact to archeologically significant areas. Depending on the density of the resources located at or near each of the areas, there may be an impact to design, location, and schedule of any construction project.

During the initial phases of a project, a KSC Environmental Checklist (Form 21-068NS) should be submitted to the NASA Environmental Program Office to determine if a planned project will impact a historic or archeological site. The Environmental Program Office will review the checklist and decide if any further action is required.

If further action is required then a Phase 1 Archeological Survey will be conducted. A Phase 1 Survey is a preliminary investigation to determine the presence or absence of historically significant sites. This investigation is done by digging small holes every 25 to 50 yards in a grid across the site.

The results of the Phase 1 Survey may require that a Phase 2 Survey be conducted. A Phase 2 Survey is an investigation to determine the scope and bounds of the sites identified in the Phase 1 Survey.

If the results of the Phase 2 Survey require a more extensive analysis, a Phase 3 Survey may be completed. A Phase 3 Survey is a full excavation of a portion of a site to accurately describe the site. While a Phase 3 Survey is the most extensive survey to be conducted, this has been executed only once at one location on KSC property (the site for the Apollo/Saturn V Center).

4.5 Areas Reserved for Other Uses

Large portions of Kennedy Space Center are undeveloped. Some currently developed areas, however, could potentially be available to support a new vertical launch site. The following areas are currently reserved for other uses.

Existing Launch Complex 39 Facilities

Currently all facilities designated for launch complex 39 are supporting the shuttle program. At or near the end of the shuttle program use of these facilities will begin migrating to support the Constellation Program and the new Crew Launch Vehicle. For the purposes of this study, it is assumed that the VAB and launch pads are reserved for other uses and are thus unavailable. Other Shuttle support buildings are as yet undetermined as useful to the Constellation program. These buildings may be available to support off site activities such as payload and vehicle processing for the vehicles defined in this study. Off site vehicle activities are not a part of this study.

Shuttle Landing Facility

The region north of the SLF was briefly considered for the vertical launch site location. The first step to explore this option was to consult the Federal Aviation Administration's Runway Design document (FAA AC 150/5300-13) to determine the limitations of use near the end of a runway. Reasonably demanding requirements for post-shuttle commercial operations were considered: Aircraft Design Group VI (tail height 66-80 ft, wingspan 214-262 ft), Aircraft Approach Category D (landings at 141-166 knots), and less than ½ mile visibility. Various geometric requirements (Runway Protection Zone, Object Free Areas, Object Free Zone, Runway Safety Areas, etc.) were applied to the end of the runway in order to establish the boundaries allowed for various activities, and then a preliminary building restriction area was determined.

Though this investigation showed that building sufficiently far from the runway (per 150/5300-13) is feasible, construction of a launch site in this area is not recommended. The reason for this is that launches in a southeasterly direction would not be allowed as a result of over-flight restrictions closer to the ocean. The data is shown here for information and comparison. The SLF proper and the restricted area immediately adjacent is reserved aircraft use.

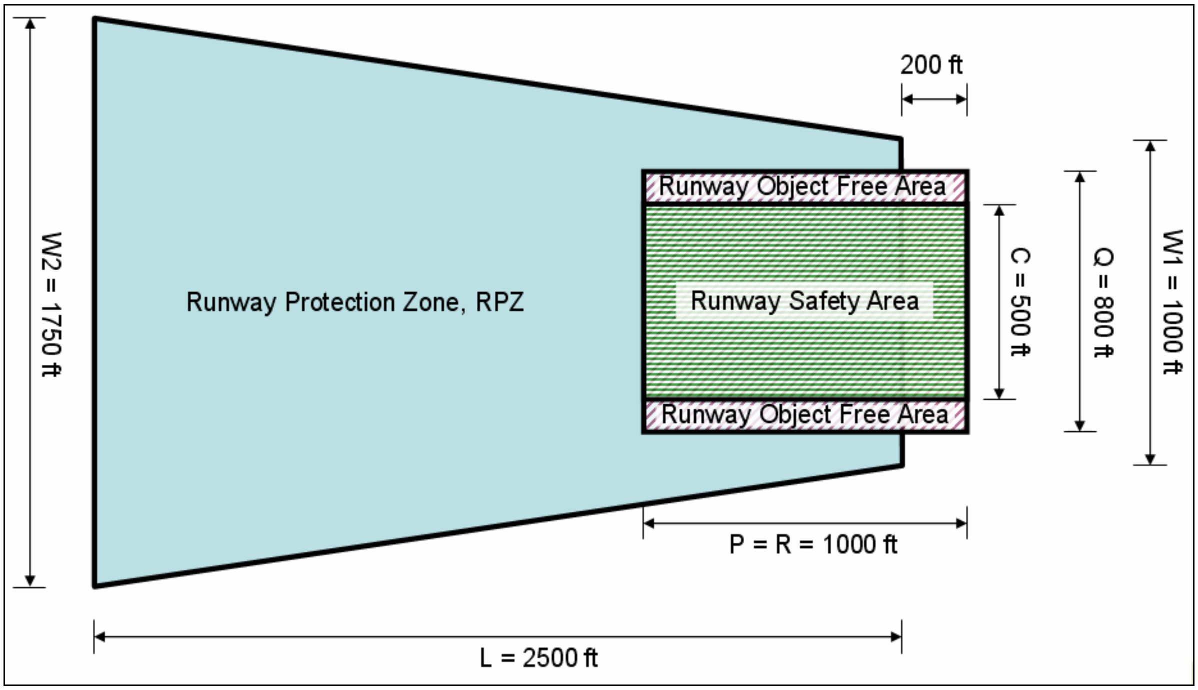


Figure 27: Minimum Dimensions for Runway Ends (D, VI, <½-mi Visibility) (Ref: [15])

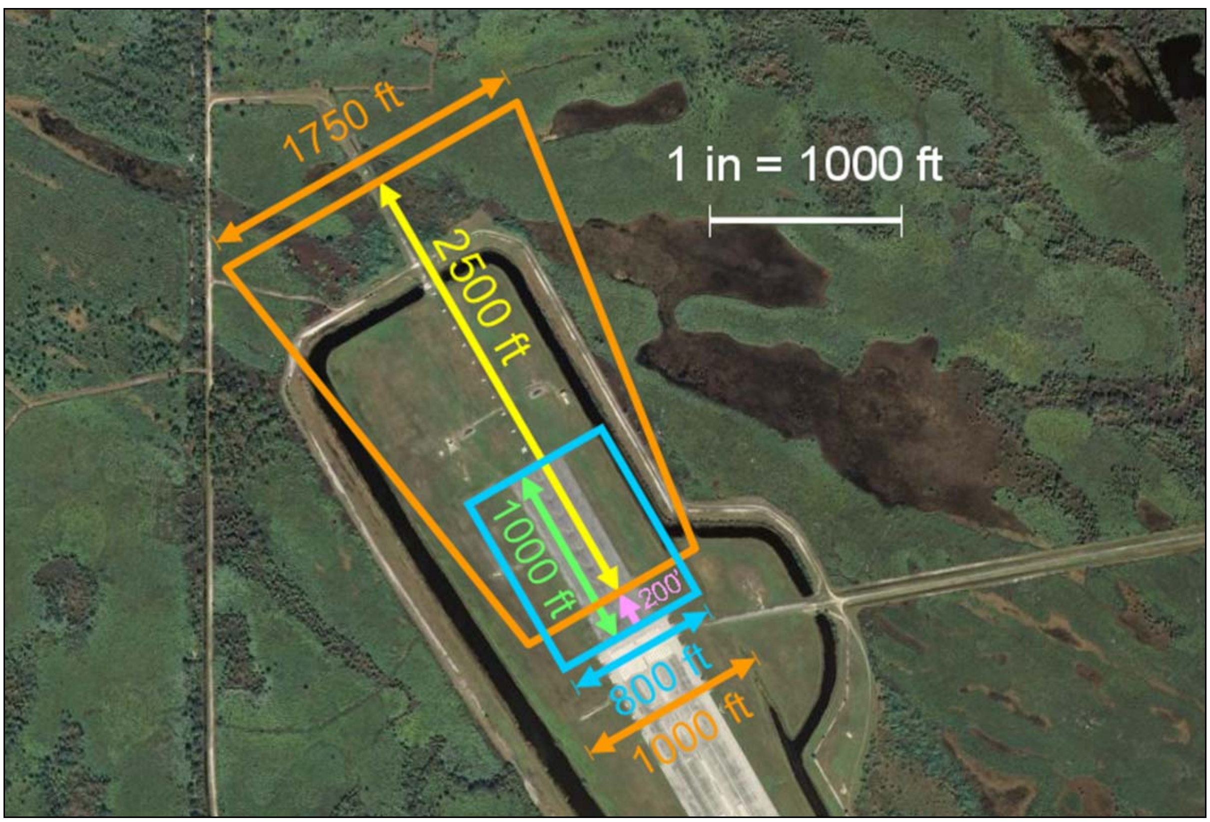


Figure 28: Runway Protection Zone and Runway Object Free Area

4.6 Launch Azimuth from Eastern Range

The angle of an orbit with respect to the equatorial plane is known as the orbital inclination ("i"); it is measured such that a 0° is an eastward (prograde) equatorial orbit, 90° is a polar orbit, and 180° is a westward (retrograde) equatorial orbit as delineated in Figure 29. The desired inclination can vary greatly from mission to mission, as each inclination has its own benefits. For example, high inclinations allow more area of earth observation whereas lower inclinations generally require less fuel.

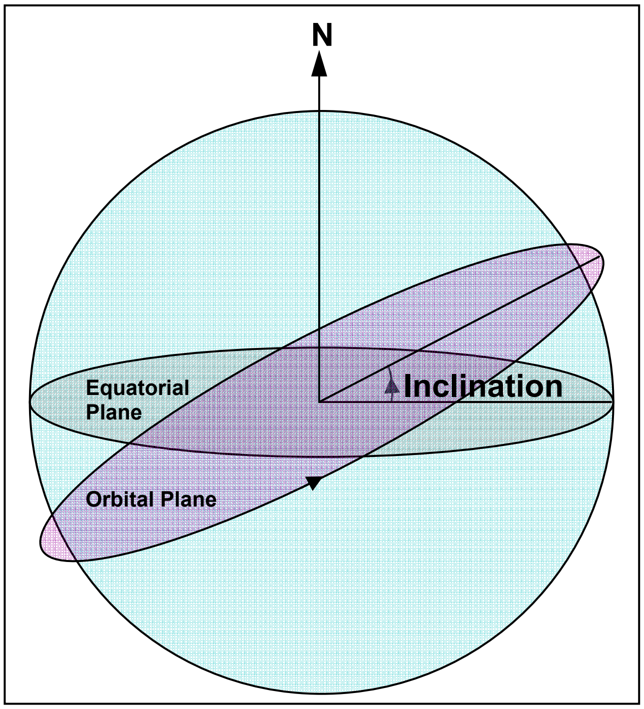


Figure 29: Inclined Orbital Plane (i=39°)

Though a launch vehicle's final inclination in earth orbit is dependent on many factors, its launch latitude ("φ") and launch azimuth ("β") are the primary determinants. The launch latitude at KSC is 28.5° and the allowable range for launch azimuths (measured clockwise from north and delineated by over-flight restrictions) for KSC is 37° to 114°. Applying these numbers gives an inclination range of 28.5° to 57° for northeast launches and 28.5° to 36° for southeast launches. See Figure 30. Note that the recurrence of 28.5° is no coincidence – the minimum orbital inclination is the same as the launch latitude unless maneuvers are performed that significantly reduce payload capacity.

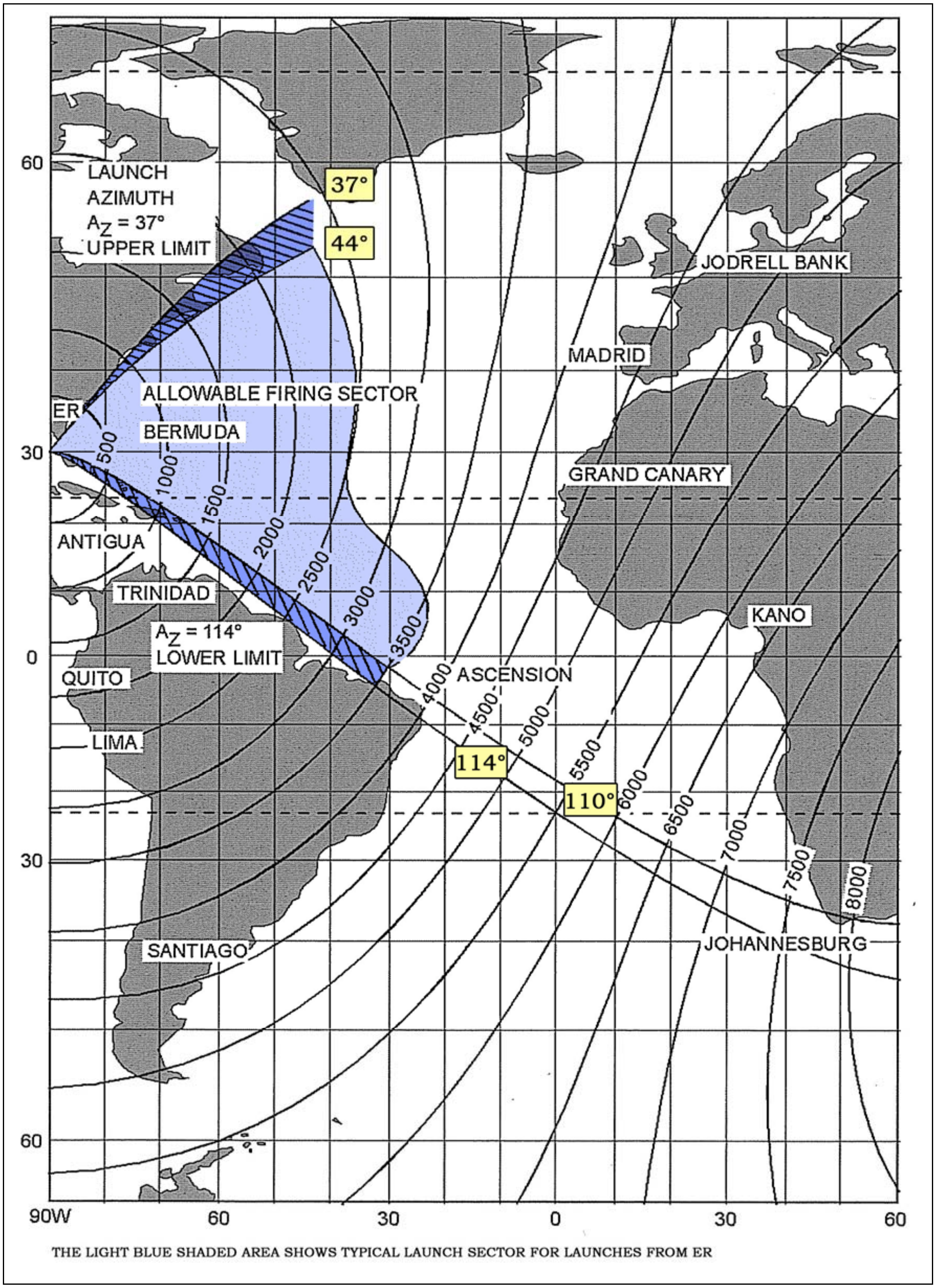


Figure 30: Typical Launch Azimuths for Eastern Range (Ref: [11])

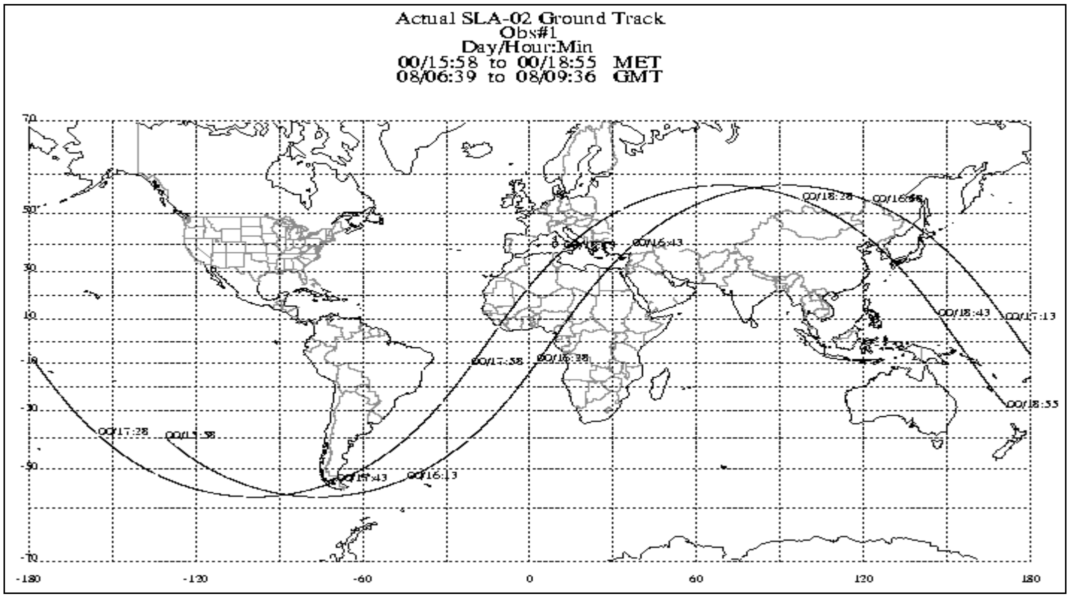


Figure 31: Ground Tracks from SLA-02, i=57° (Ref: (A))

Although southeast launches from KSC yield orbital inclinations that can be achieved just as well by launching northeast, the inclination is not the only orbital element of importance. The orbital plane can be rotated along the earth's axis without affecting the orbital inclination, meaning that an infinite number of different ground tracks can be achieved by a single inclination. In order to have a fully constrained orbital plane, there can only be one point where the orbital plane crosses the equator when moving from south to north; this point is known as the ascending node. The ascending node is relevant in that it defines which parts of the earth the orbiting body will pass over, and this will be affected by whether the launch is angled northeast or southeast. See Figure 31 and Figure 32.

Most orbits do not place limitations on the location of the ascending node, since a specific inclination is all that is required to fulfill most mission requirements. In fact, nodal regression (motion of the orbital plane resulting in motion of the ascending node) occurs naturally, allowing orbiting bodies to eventually cover any necessary ground within the appropriate inclination. However, some missions require very specific orbital planes and thus very specific ascending node locations; these missions tend to be those requiring orbital rendezvous or interplanetary travel. In order to maximize the number and types of missions that can be launched from the chosen site, both northeast and southeast maximum allowable launch azimuths are used as a discriminating criteria.

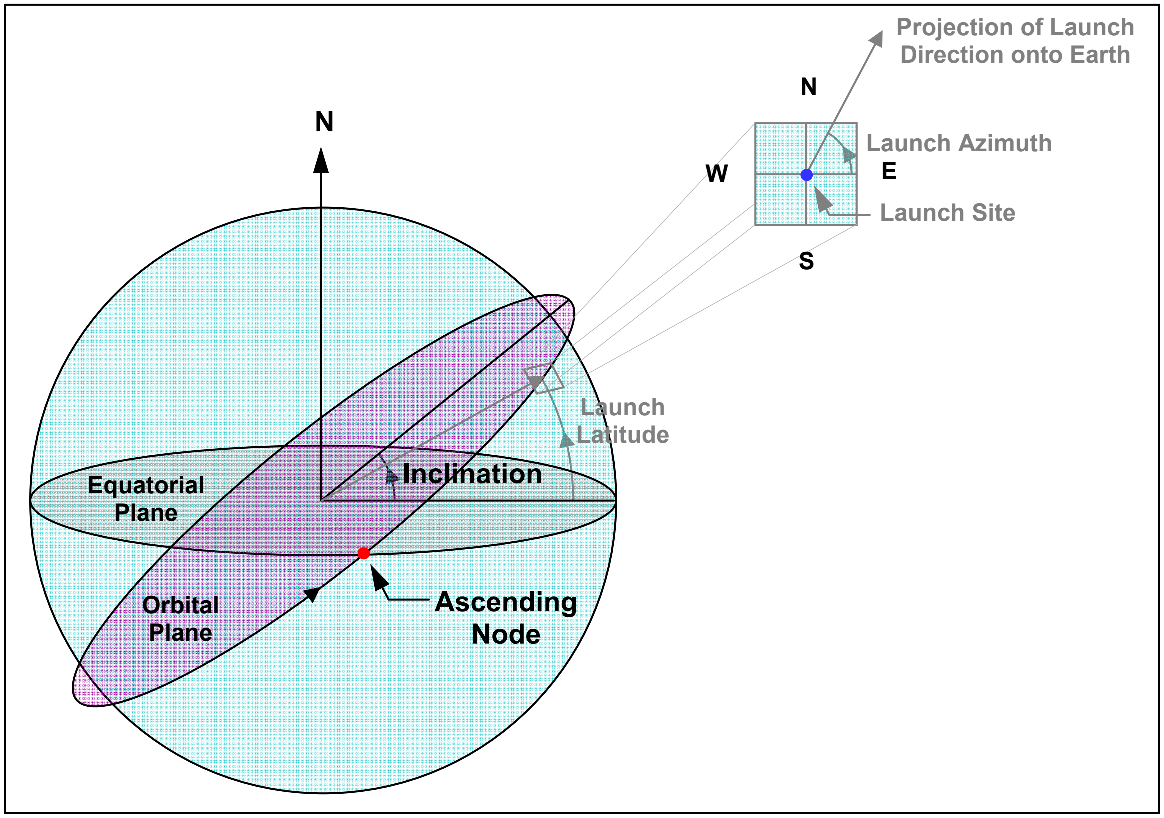


Figure 32: Orbital Elements with Launch Characteristics (φ=28.5°, β=61°, i=39°)

The downside of allowing the full range of launch azimuths (37° to 114°) to occur is that the areas available for the launch site decrease with an increase in the launch azimuth range: over-flight restrictions prevent rockets from traveling within certain distances of populated areas, national assets, and other locations. Northeast launches are imperative for re-supply missions to the ISS, and the KSC area layout is well-suited to northeast launches in that over-flight issues at that azimuth are minimal. However, accommodating southeast launches can preclude some locations from potential development as a launch site, as many national assets are located southeast of some otherwise-suitable potential launch sites. Despite the geographic limitations imposed by-over-flight disadvantages, it is important to provide the mission flexibility that can only be achieved by locating a launch site such that the location allows the full range of azimuths possible from KSC.

4.7 Flyover Restrictions at KSC

The illustration in Figure 33 indicates the KSC property available for launch site development, in white, after deleting the land precluded from use by over-flight restrictions, shown in orange.

Each candidate vehicle will have its own debris field parameters based on its unique launch performance, propellant loads, etc. Because debris field characteristics vary throughout vehicle flight profiles and each is unique to each vehicle, consideration of such variances were not initially accommodated when delineating the above usable areas. Instead, a line at the maximum allowable azimuth angle was drawn tangent to existing facility perimeters. This provides a solid line against which individual vehicle characteristics, when known, may be compared. Note that vast tracts of KSC property are excluded.

The usable areas are primarily north of a line drawn from Pad 39B through a point two miles north of the north end of the Shuttle landing Facility. Three other triangular shaped areas appear along the Atlantic Ocean shoreline south of that line. The area between Pads 39 A and B is too small to provide adequate space for the typical layout shown in Figure 7. This is particularly evident when the Pad 39 QDs are overlaid on to the area. Two other triangular areas of opportunity appear south of Pad 39A. All areas will be discussed in detail in the next section.

If the southerly azimuths are precluded from consideration for the candidate vehicles, Figure 34 shows the land then available for launch site development. If the possibility for northern and eastern launches only is acceptable, several more possible areas for development are revealed. They are shown here for reference and comparison. For this study, sites will be considered only if they allow access to the full array of launch azimuths available at KSC.

Figure 35 shows the available areas for consideration with Eagles nests and Scrub Jay habitat areas overlaid upon the entirety of KSC property.

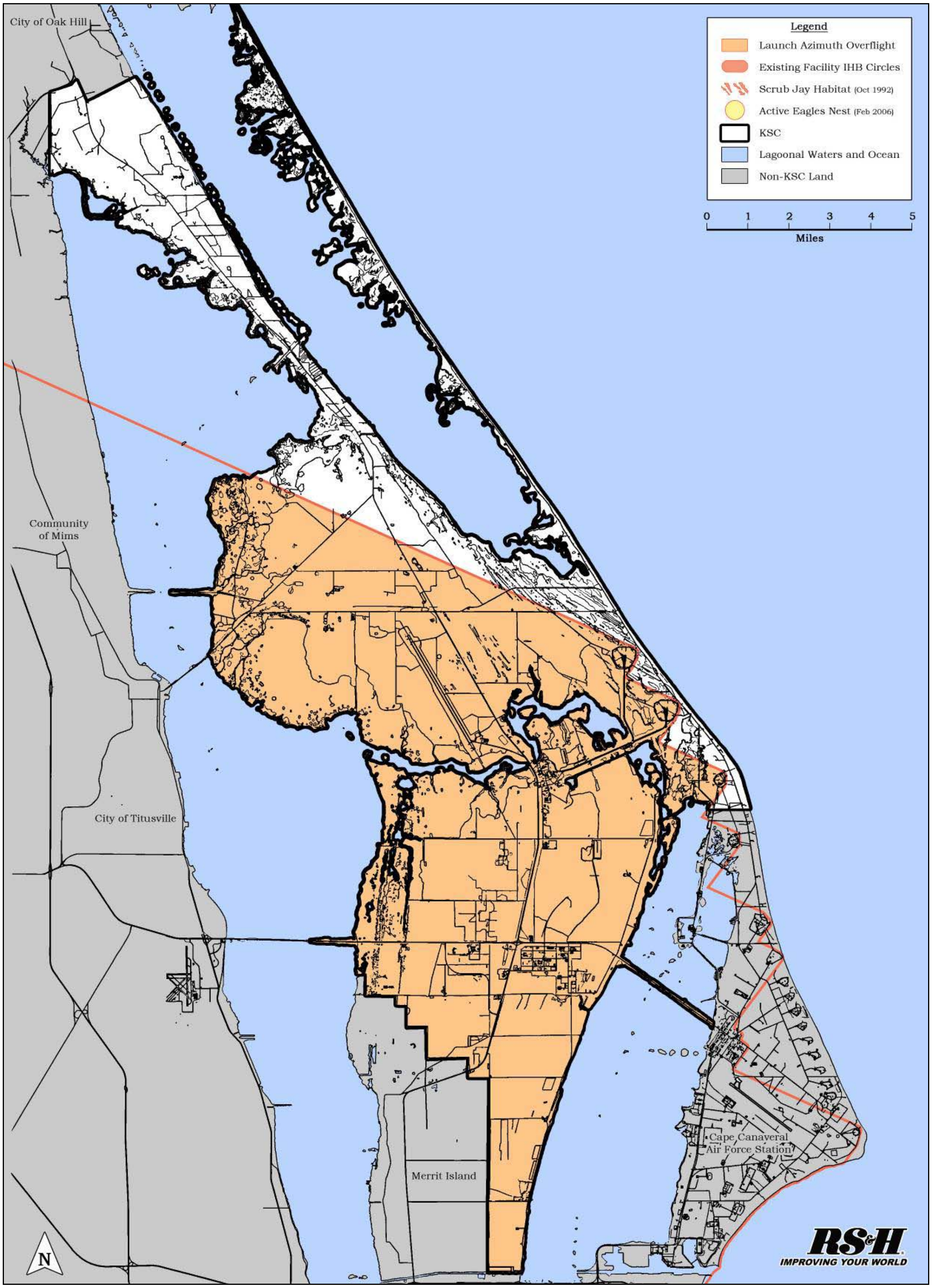


Figure 33: Flyover Restrictions for Typical Launch Azimuths

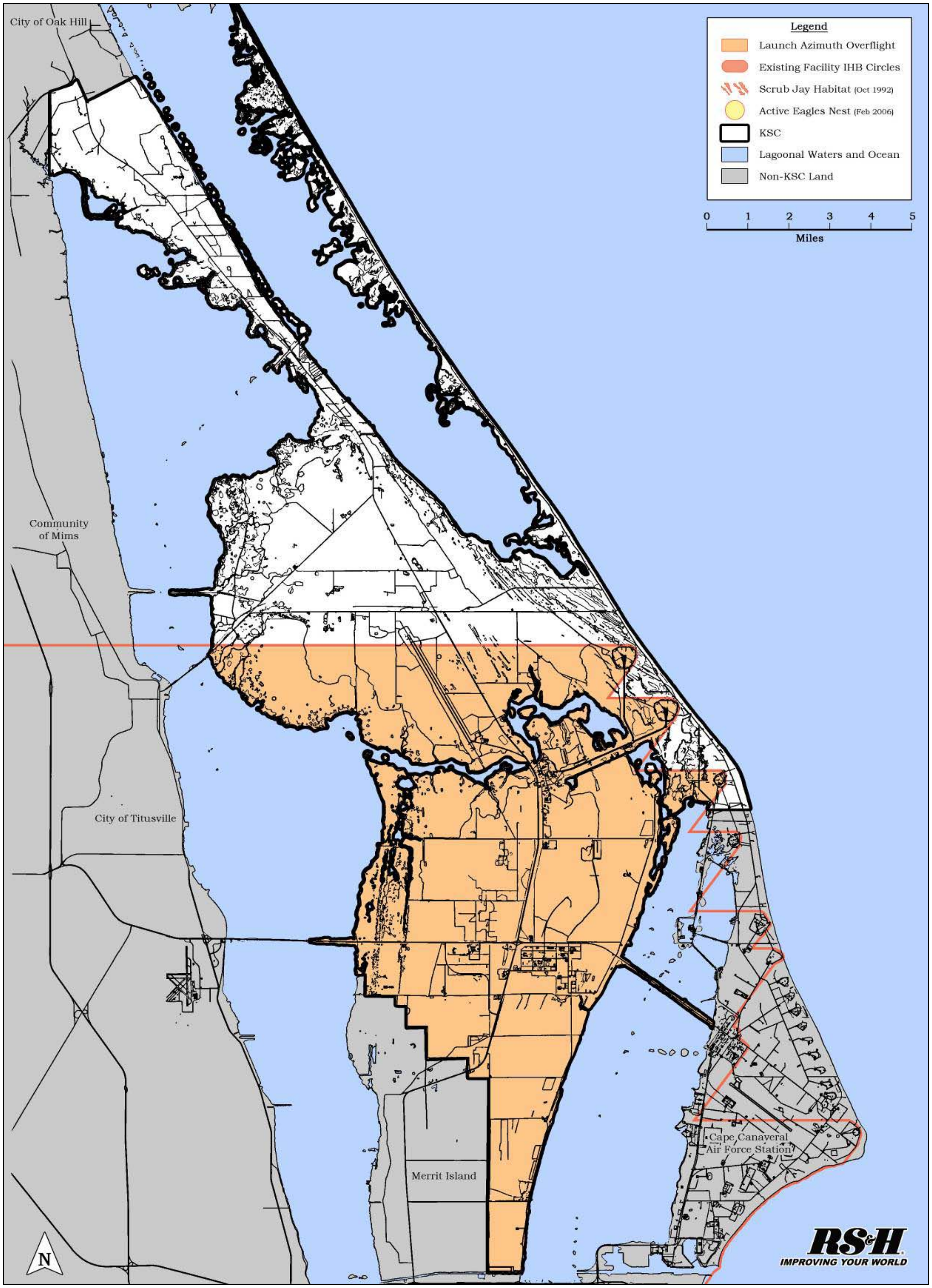


Figure 34: Flyover Restrictions for Modified Launch Azimuths

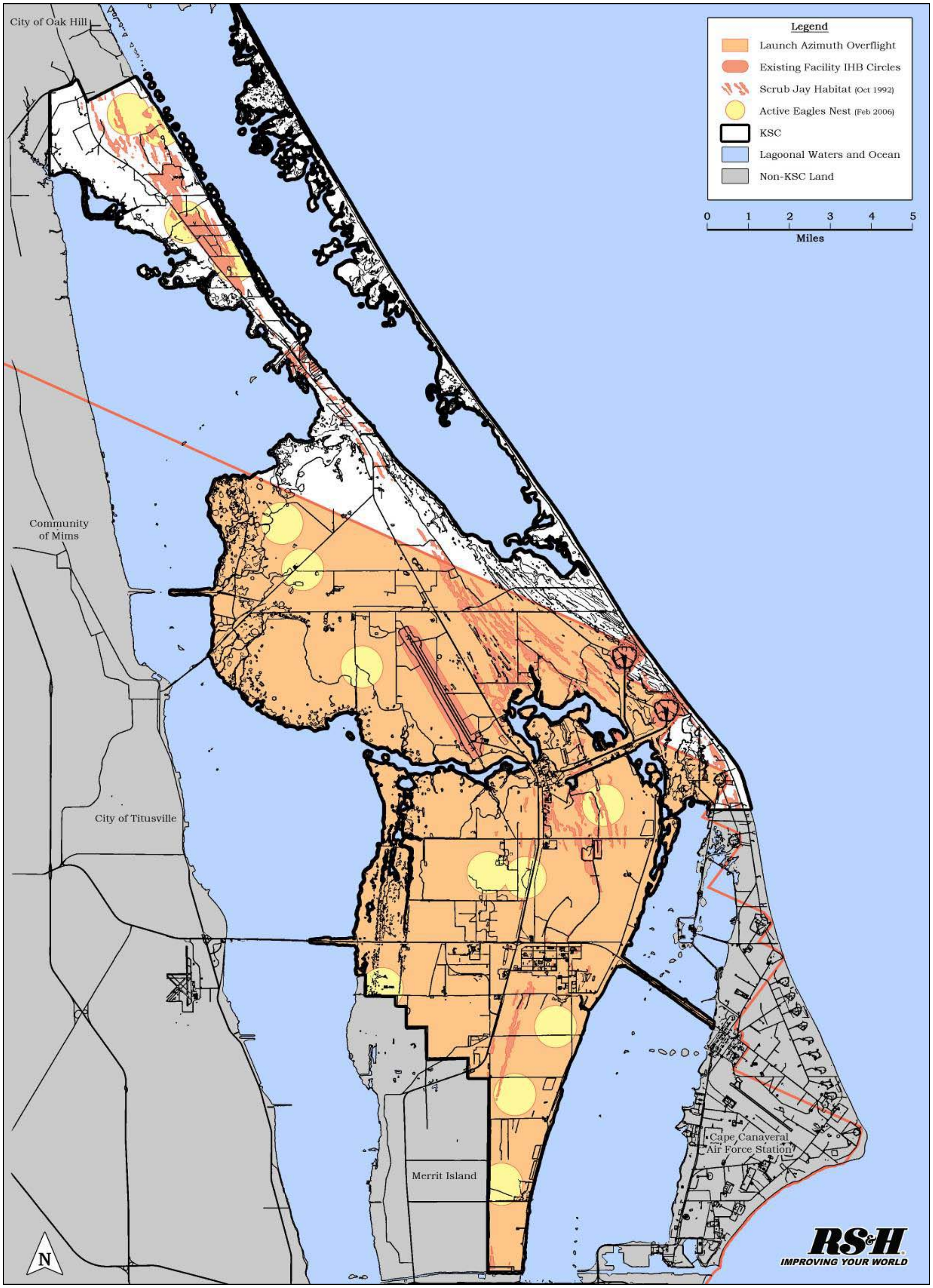


Figure 35: Flyover Restrictions for Typical Launch Azimuths with an overlay of Eagle's nest and Scrub Jay habitat areas.

Section V: Vertical Launch Site Survey

In this Section, ten candidate areas are selected based on the flyover restrictions identified in Section 4. The boundaries for these ten areas are shown along with brief descriptions of each. In Section 6, these ten areas are evaluated based on initial pass / fail criteria with the remaining areas being evaluated further in Section 7.

5.1: Identification of Candidate Vertical Launch Areas

Figure 35 from Section 4 shows, in white, the clear areas remaining on KSC property that avoids flyover of existing launch facilities. The candidate areas have been selected from this clear area to ensure that during a typical mission a launch vehicle will not fly over existing launch facilities.

The shapes of the remaining land areas did not readily lend themselves to being marked off in a Cartesian grid. To separate the potential areas for study the areas were thence chosen from a moderate scaled map with the following criteria:

- No attempt was made to prejudge any area.
- The minimum size of any area appeared large enough to accommodate the Typical Site Layout shown in Figure 7.
- Some delineating man-made or natural geophysical or political feature divided one from another.

Figure 36 shows the designated areas on a map with existing features clearly discernable. Figure 37 shows the coverage of the designated areas.

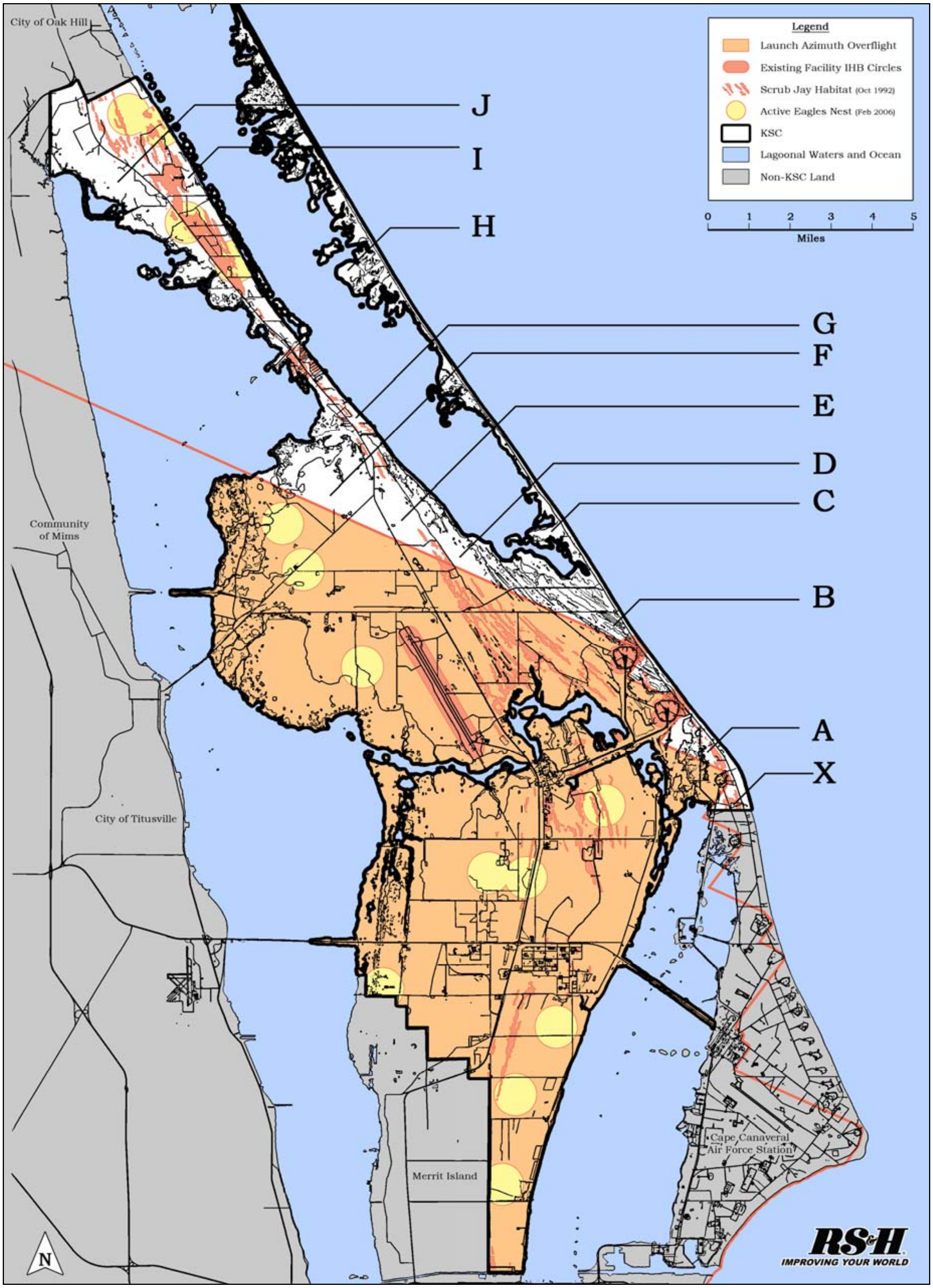


Figure 36: Candidate Launch Area Labels

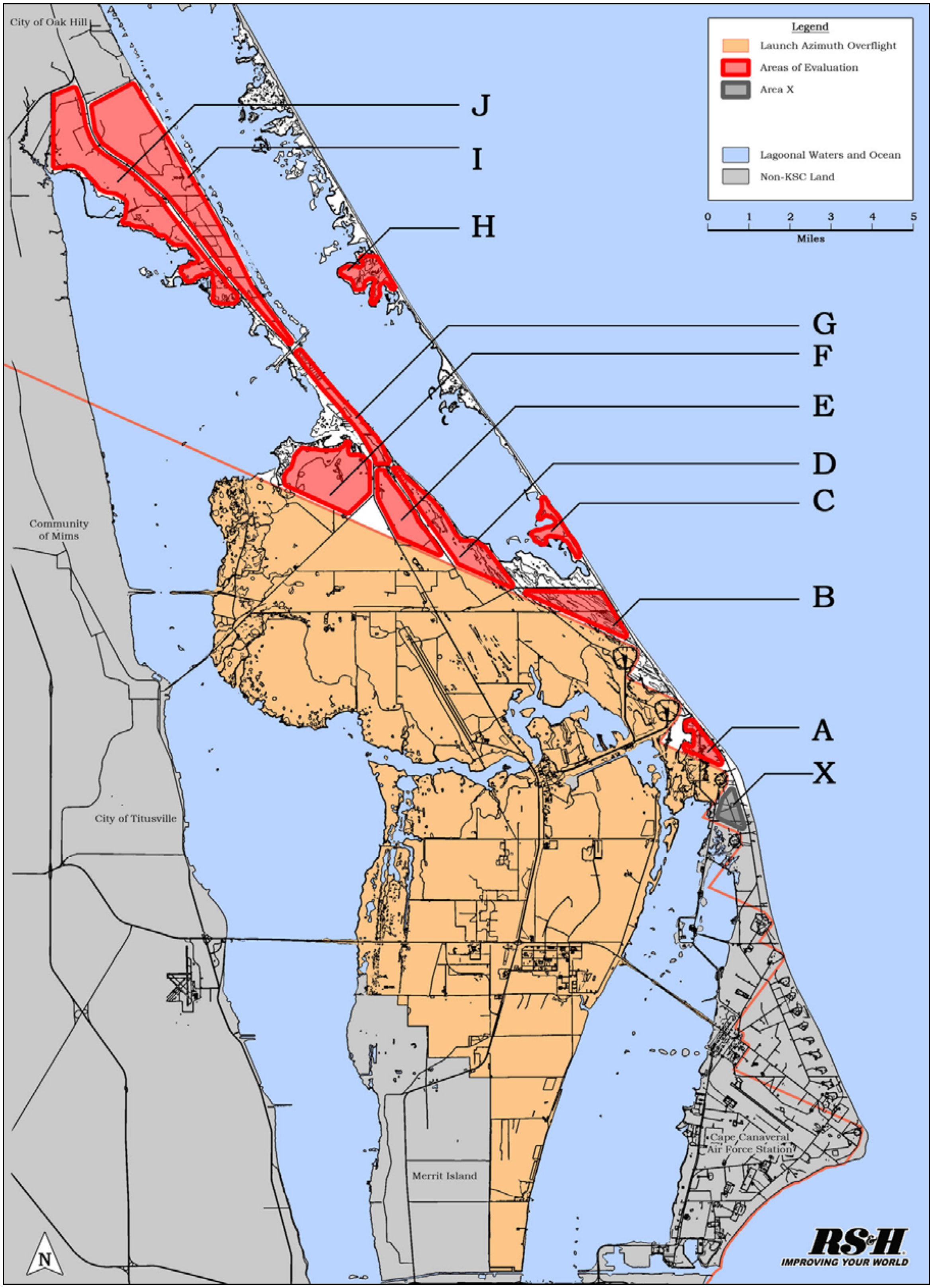


Figure 37: Candidate Launch Areas

5.2 Area A

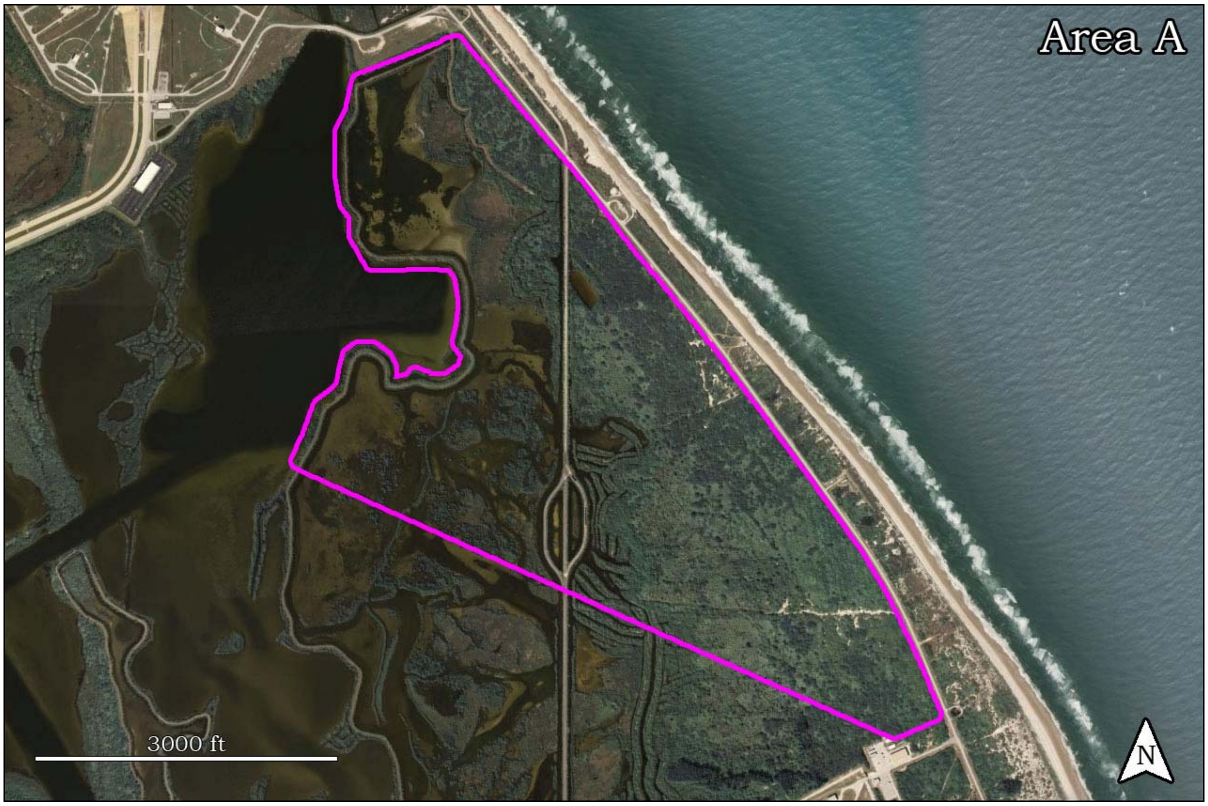


Figure 38: Area A

North	Pad 39A perimeter
East	Atlantic Ocean
South	Cx-40 perimeter and Cx-40 Flyover Constraint
West	Primarily the CCAFS rail road tracks and ultimately Gulbrandson Creek

Area A exhibits enough dry land to easily accommodate the prototype facility with minimal fill required. Designated Scrub Jay habitat exists throughout the area. It has existing rail and road access in addition to the potential for barge access for delivery of flight components. Area A resides between Pad 39A and Cx-41 therefore careful consideration is required to ensure that a launch facility placed here does not interfere with existing, adjacent launch operations. Additionally, existing launch operations at CCAFS and KSC can affect processing at the new prototype facility through reduced access to Area A as hazardous operations occur at neighboring facilities.

5.3 Area B

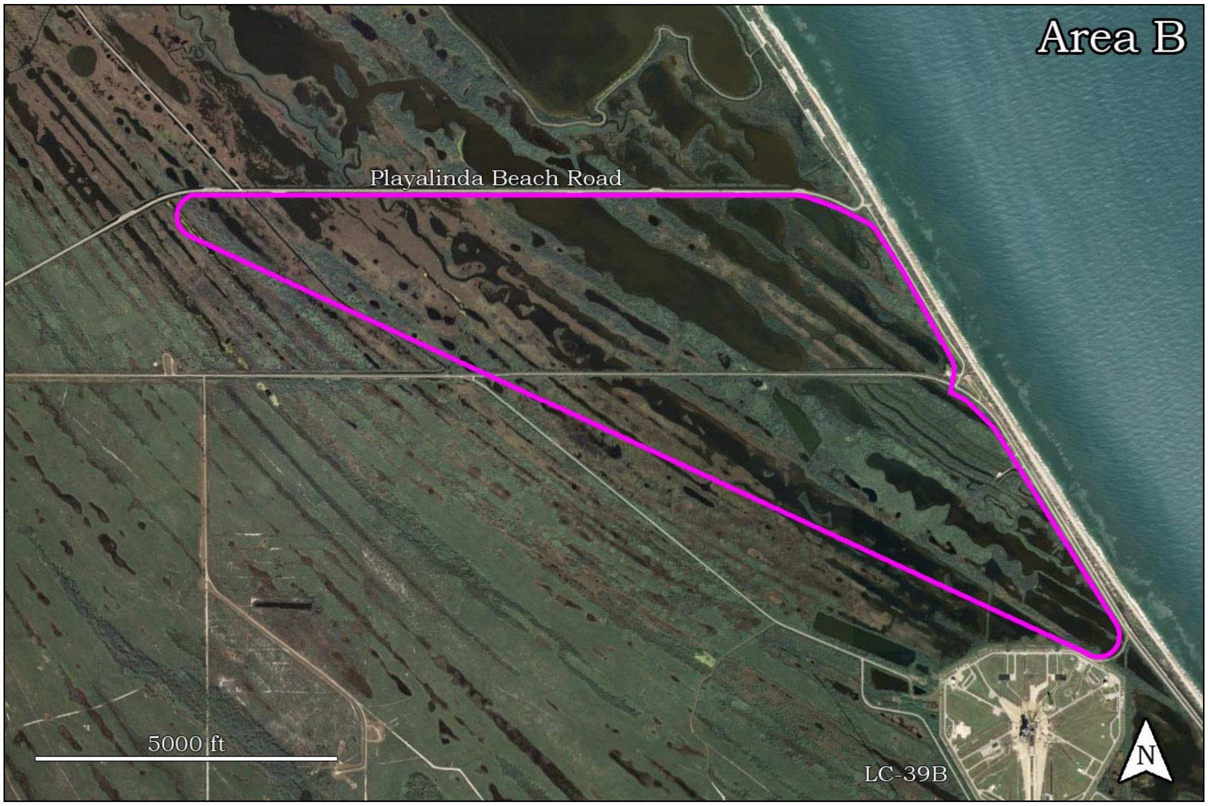


Figure 39: Area B

North	Playalinda Beach Road
East	Atlantic Ocean
South	Pad 39B perimeter, and LC-39B Flyover Constraint
West	The confluence of Playalinda Beach Road and LC-39B Flyover Constraint

Area B consists of a mixed water/land combination that is similar to that of Pad 39B prior to initiation of construction. Large amounts of fill were dredged from the surrounding region to create Pad 39B which was acceptable in the 1960's. Doing so today will create the need to mitigate the wetlands destroyed during the filling process. This does not necessarily preclude Area B from consideration. Area B has existing road and rail access. Use of Area B will initiate issues with the public over increased Playalinda Beach Road closures or relocation and the possible mitigation of any access to Canaveral National Seashore property lost in the development process.

5.4 Area C

Figure 40: Area C

North	Eddy Creek
East	Atlantic Ocean
South	Playalinda Beach Parking Lot #4
West	Max Hoeck Creek/Pelican Island

Area C consists largely of shallow water although on smaller scale maps, as shown above, it might appear otherwise. Additionally any development at Area C will drastically affect public seashore access and create large scale mitigation measures for both the wetlands destroyed and lost National Seashore access.

5.5 Area D

Figure 41: Area D

North	Confluence of existing road/trail and the Mosquito Lagoon shoreline
East	Mosquito Lagoon
South	Over-flight line from Pad 39B
West	Eastern road/trail parallel to Kennedy Parkway North (SR-3)

Area D is comprised of impounded waters and hydric soil. Scrub Jay habitat is minimal. Proximity to State Road 3 will initiate public discourse over road closure and/or relocation of S.R. 3 and Playalinda Beach Road. These closures could be possible due to vehicle integration procedures and commodity storage issues as well as a fully fueled vehicle on the pad. The area is within 6.5 miles of publicly inhabited land and structures on the mainland. Launches from this area would over-fly Mosquito Lagoon, S.R. 3 and the Canaveral National Seashore, all of which would be closed during fueling and launch.

5.6 Area E

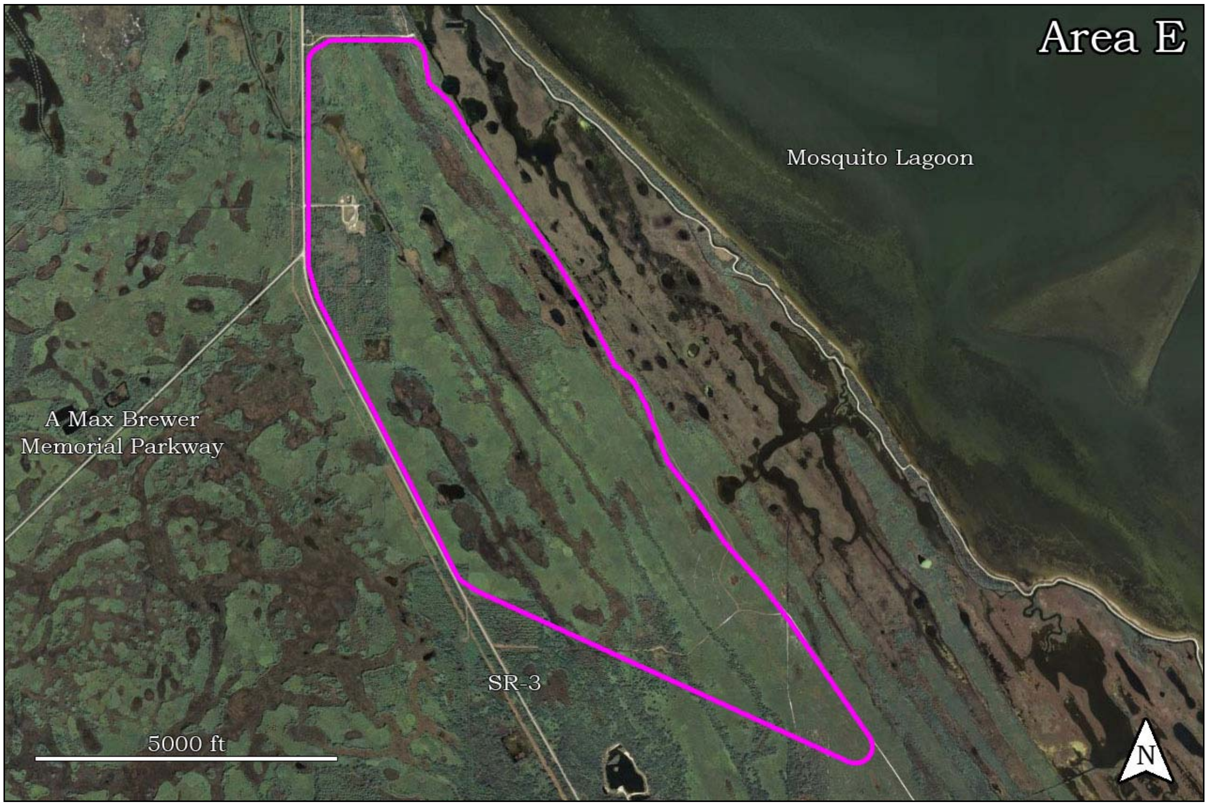


Figure 42: Area E

North	Existing road/trail 0.7 mi North of Confluence of A Max Brewer Memorial Parkway and SR-3
East	Existing road/trail parallel to Kennedy Parkway North (SR-3)
South	Over-flight line from Pad 39 B
West	State Road 3

Area E is comprised of largely dry, acceptable land for development. Scrub Jay habitat is minimal. Proximity to State Road 3 will initiate public discourse over road closure and/or relocation of S.R. 3. This closure could be possible due to vehicle integration procedures and commodity storage issues as well as a fully fueled vehicle on the pad. The area is more than 6.5 miles from publicly inhabited land and structures on the mainland. Launches from this area would over-fly Mosquito Lagoon and the Canaveral National Seashore. SR-3, Mosquito Lagoon and Canaveral National Seashore would all be closed during fueling and launch.

5.7 Area F

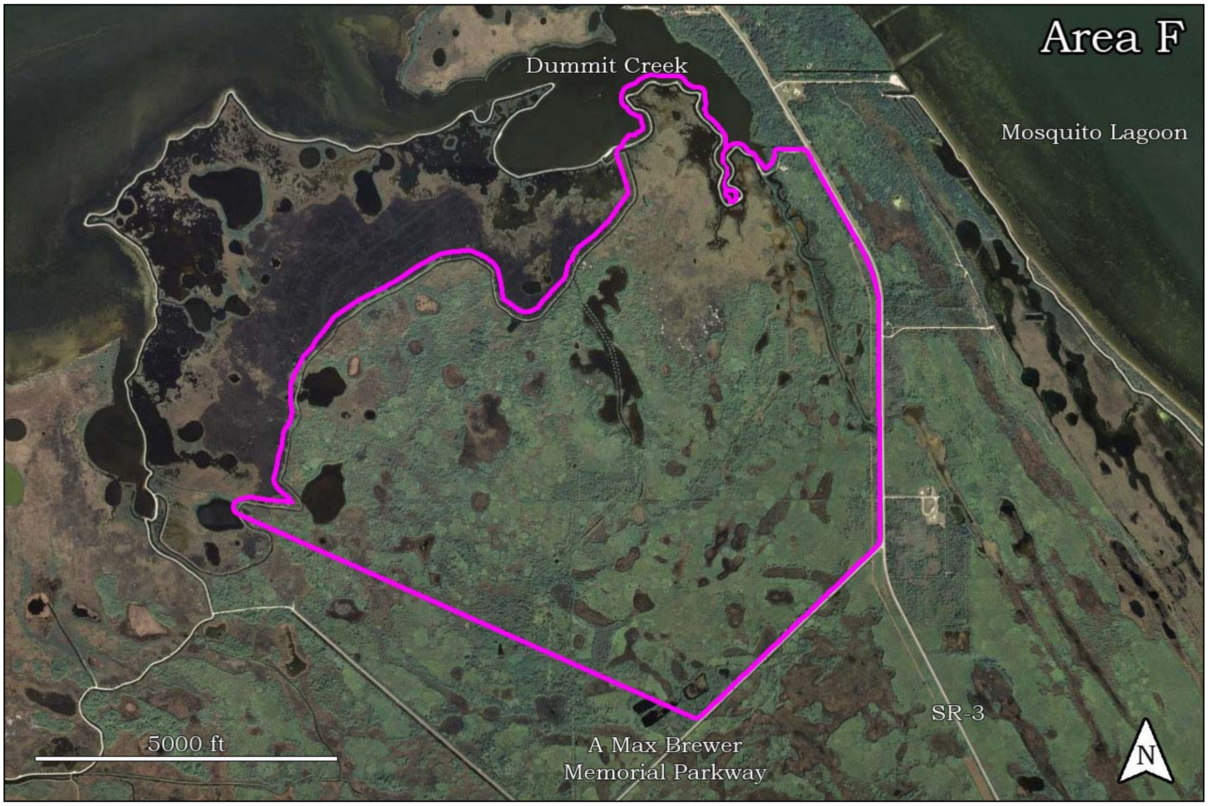


Figure 43: Area F

North	Dummit Creek
East	State Road 3
South	A Max Brewer Parkway
West	Existing road/trail

Area F is comprised of largely dry, acceptable land for development. Scrub Jay habitat is moderate. Proximity to State Road 3 will initiate public discourse over road closure and/or relocation of S.R. 3. This closure could be possible due to vehicle integration procedures and commodity storage issues as well as a fully fueled vehicle on the pad. Some portions of the area are less than 5 miles from publicly inhabited land and structures on the mainland. A large dry area large enough for the vertical launch site is located over 5.5 miles from publicly inhabited land. Launches from this area would over-fly Mosquito Lagoon, S.R. 3 and the Canaveral National Seashore, all of which would be closed during fueling and launch.

5.8 Area G

Figure 44: Area G

North	Haul Over Canal
East	Mosquito Lagoon
South	Existing road/trail
West	State Road 3

Area G is a narrow spit of land between the Indian River estuary and Mosquito Lagoon. It is comprised of largely of dry, acceptable land for development. Scrub Jay habitat is moderate. Proximity to State Road 3 will initiate public discourse over road closure and/or relocation of S.R. 3. This closure could be possible due to vehicle integration procedures and commodity storage issues as well as a fully fueled vehicle on the pad. The area is slightly more than 6 miles from publicly inhabited land and structures on the mainland. Launches from this area would over-fly Mosquito Lagoon and the Canaveral National Seashore. SR-3, Mosquito Lagoon and Canaveral National Seashore would all be closed during fueling and launch.

5.9 Area H

Figure 45: Area H

North	Mosquito Lagoon
East	Atlantic Ocean
South	Widgeon Bay
West	Mosquito Lagoon

Area H is located approximately 10.5 miles northwest of Pad 39B. Even though Area H appears as solid ground on small scale maps, it is largely submerged.

5.10 Area I

Figure 46: Area I

North	Confluence of U S 1 and State Road 3
East	Kennedy Parkway North/State Road 3
South	Griffin Bay
West	Indian River shore

Area I is upland citrus grove and oak/pine woodlands. It is less than 3 miles from publicly inhabited lands.

5.11 Area J

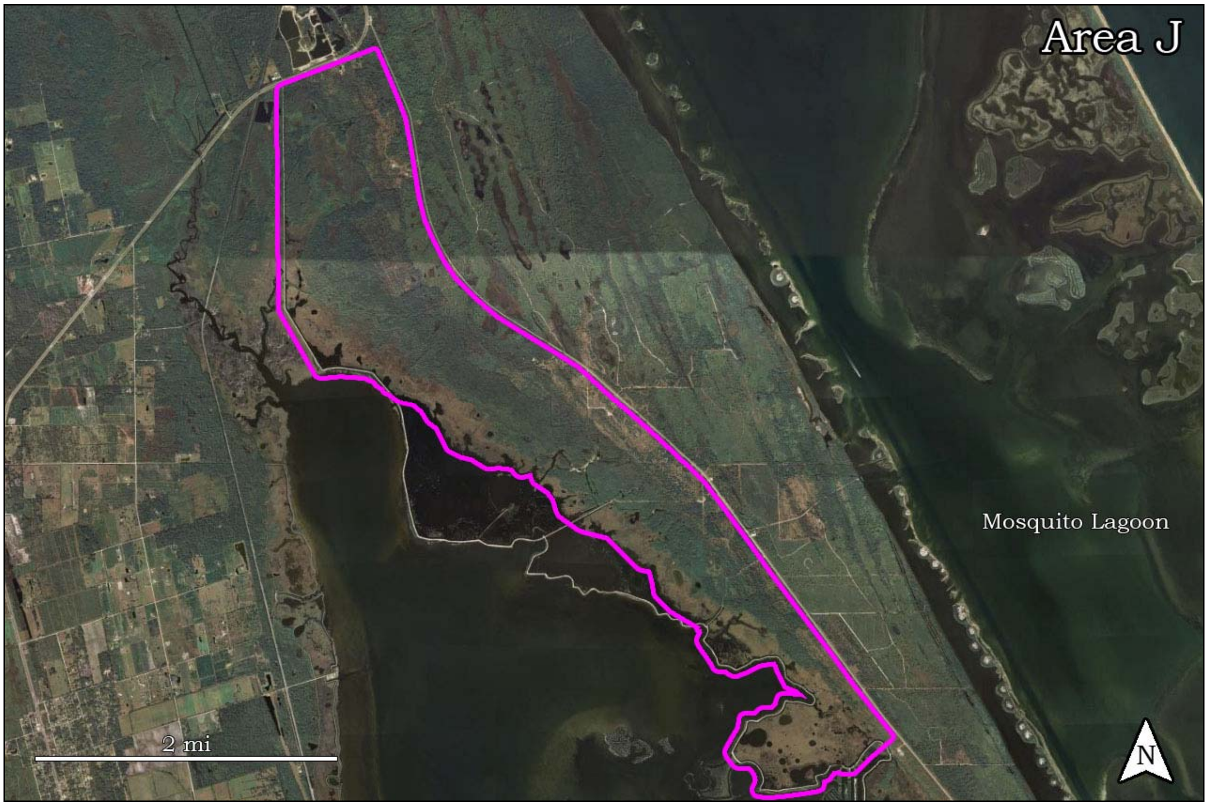


Figure 47: Area J

North	KSC boundary
East	Mosquito Lagoon
South	Haul Over Canal
West	Indian River Shore

Area J is upland citrus grove and oak/pine woodlands. It is surrounded by several Eagles' nests and is more than 50% Scrub Jay habitat. It is less than 2 miles from publicly inhabited lands.

5.12 Area X

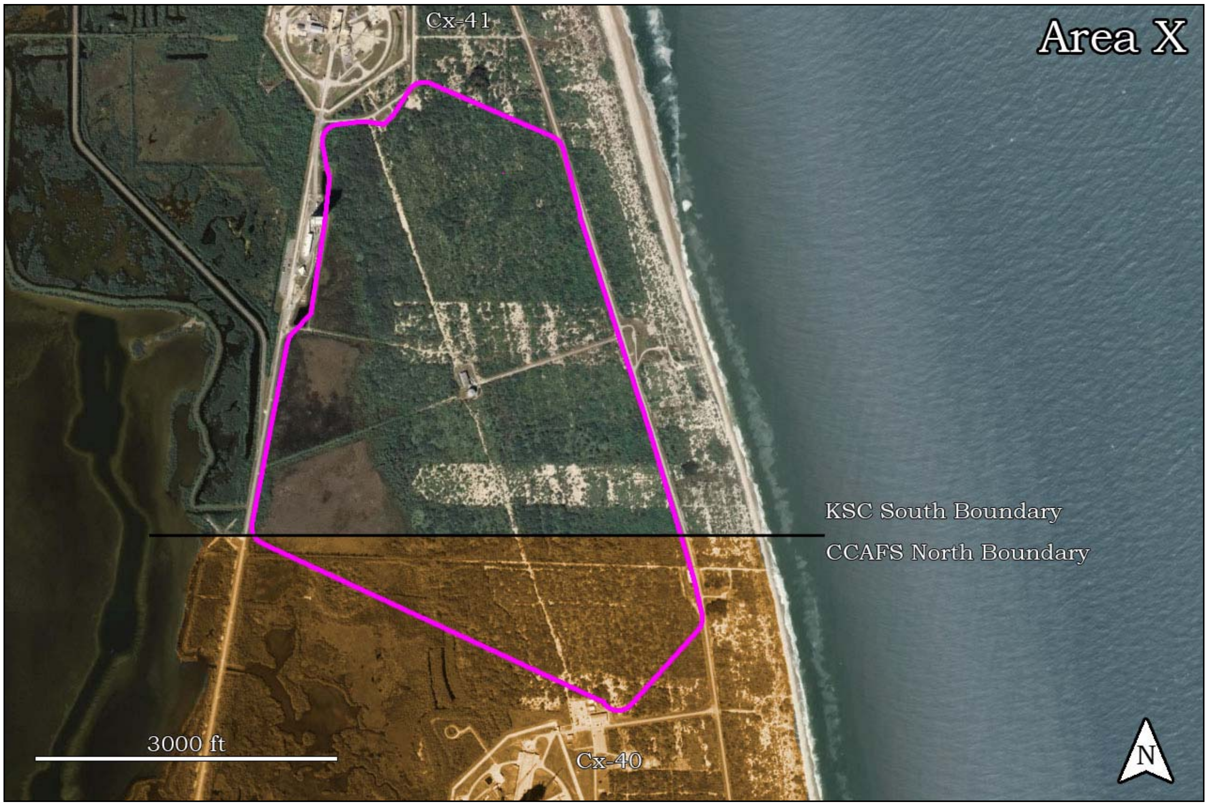


Figure 48: Area X

North	Cx-41 perimeter
East	Atlantic Ocean
South	South KSC boundary
West	Water area impounded by Titan IV causeways

Area X, as denoted on the map , indeed appears as a nearly viable area for launch site development based on launch azimuth criteria. However area X currently appears too small to support the Typical Site Layout shown in Figure 7. The southern half of the area is outside of the bounds of Kennedy Space Center. As such it is not considered in this study.

Historically agreements between the USAF and NASA in this region of the Cape have resulted in a shifting of boundaries to accommodate specific launch requirements for the Titan launch pad at Cx 41. A future similar agreement ceding or leasing Air Force land to NASA could enlarge Area X to the full extent shown by the red azimuth line drawn from Cx 40.

Section VI: Initial Area Evaluation

Two methods are used to evaluate the differences between the previously identified candidate areas. This Section takes the first step in the evaluation by developing Pass/Fail criteria used to down-select the areas for further evaluation. Candidate areas passing the preliminary evaluation are placed in a secondary evaluation matrix in Section 7 utilizing numerical values of 1 to 5 within each criteria with 5 being the most favorable. Each criteria was then assigned an overall significance factor.

The logic for separating the evaluation into two steps is derived from the knowledge that the values for some discriminators are difficult to show in a Pass/Fail only format. Of the many discriminating categories only a few were found that could not be mitigated in some manner. Often mitigation resulted in increased schedule duration and/or increased costs. Neither an increase in cost, nor an increase in schedule indicates a 'Fail' rating.

6.1 Initial Criteria and Discussion

A total of 10 candidate launch areas were identified on KSC property and shown in Figure 37. To identify which areas justify a more detailed evaluation and comparison, an initial Pass/Fail evaluation is conducted on several discriminating factors. The Pass/Fail criteria used at this level of evaluation are:

1) Existing Launch Facilities Over-flight
2) Proximity to Residential Areas
3) Available Land Area
4) Category 1 Hurricane Tidal Surge

Existing Launch Facilities Over-flight

As presented in Section 4.7 one discriminating factor for the selection of a new area is to prevent the possibility of a launch vehicle flying over an existing pad or facility. Figure 33 shows the flyover restrictions for typical launch azimuths. All candidate areas have been selected to avoid over-flight of existing launch facilities.

Proximity to Residential Areas

To increase the level of safety to the public, a proximity limit is used for the evaluation criteria. The distance of 5 miles was selected as that is the distance from Launch Complex 36 to public areas on the south side of CCAFS. Since launch Complex 36 has been used in the past for NASA and other missions in the Atlas program and is currently being considered as a launch site for another launch vehicle it is deemed to be a safe distance from the public. Both candidate launch areas I and J are less than 5 miles from residential areas therefore these areas have been identified as failing to meet this criteria.

Available Land Area

A minimum of 150 acres is estimated as being the minimum required for a new vertical launch site similar to the one identified in Figure 7. All of the candidate launch areas have sufficient acreage however not all areas have contiguous dry land sufficient for building the launch pad. In these instances large amounts of fill will be required along with possible wetland mitigation. Wetland mitigation is not decisive in the Pass /Fail criteria but is considered in the next phase of the launch area evaluation.

Category 1 Hurricane Tidal Surge

Each hurricane season the possibility exists for a hurricane to strike KSC. The effects of tidal surge are known to be more severe that that of the wind. To reduce the possible impact of hurricane tidal surges this evaluation eliminates all areas that are susceptible to the effects the tidal surge from a Category 1 Hurricane. Candidate areas B, C, G, H, and J each have sufficient infiltration of a tidal surge to disallow them from passing this evaluation.

6.2 Results of Initial Evaluation

The results of the initial evaluation are shown in the following table. Out of the 10 candidate launch areas only four of the areas passed and have been selected for further evaluation. Areas I and J are considered to be too close to residential areas, while Areas B, C, G, H, and J are within the Tidal Surge range of a Category I hurricane.

Table 11: Initial Area Evaluation – Pass / Fail Criteria

Site Evaluation - Pass / Fail Criteria						
	Minimum Requirement	A	B	C	D	E
Existing Launch Facilities Overflight	No Overflight	Clear	Clear	Clear	Clear	Clear
Proximity to Residential Areas	5 mi	12.5	9.5	9.5	7.5	6.5
Available Land Area	150 acre	400	1000	200	1200	1000
Category 1 Hurricane Tidal Surge	Safe	Safe	**Surge**	**Surge**	Safe	Safe
All Criteria Must Meet Minimum Requirement to Pass		**Pass**	**Fail**	**Fail**	**Pass**	**Pass**
	Minimum Requirement	F	G	H	I	J
Existing Launch Facilities Overflight	No Overflight	Clear	Clear	Clear	Clear	Clear
Proximity to Residential Areas	5 mi	5.5	6	7	**4**	**3.5**
Available Land Area	150 acre	1300	600	400	3800	2500
Category 1 Hurricane Tidal Surge	Safe	Safe	**Surge**	**Surge**	Safe	**Surge**
All Criteria Must Meet Minimum Requirement to Pass		**Pass**	**Fail**	**Fail**	**Fail**	**Fail**

The results of Table 11 are shown graphically in Figure 49. The candidate areas identified as meeting the minimum requirements to pass are highlighted in green. These areas are Area A, D, E, and F.

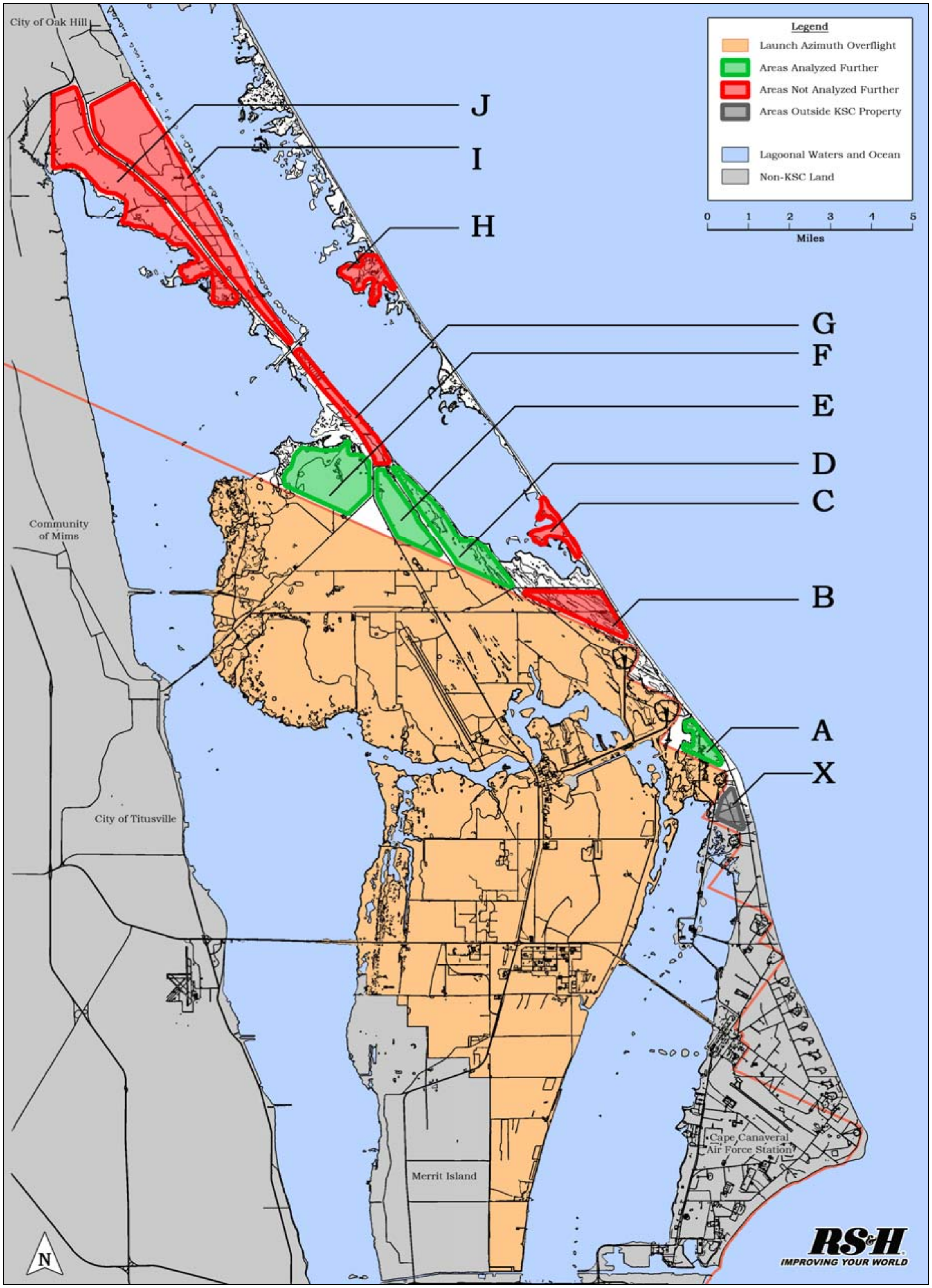


Figure 49: Candidate Launch Areas (Pass / Fail)

Section VII: Further Area Analysis

The results of the Initial Area Evaluation reduce the total number of candidate areas from ten to four. These four areas are now analyzed further based on a numerical “figures of merit” evaluation. The evaluation takes into account a wide range of criteria ranging from safety issues to environmental concerns and correlates them with a numerical rating system.

For each item listed under the evaluation criteria a weight is given which governs the relative influence of that item on the final score for each area. The weight value is an assigned value between 10 and 100 based on knowledge and experience with the individual criteria. A value of 10 has the lowest amount of influence and typically assigned to items that can be easily mitigated or designed around. A value of 100 has the highest amount of influence and is typically given to items that provide a safety concern.

For each area being evaluated a rating value between 1 and 5 is assigned for every line item presented the evaluation criteria. Higher numerical values indicate a ranking of higher merit. Figure 50 provides an example table and chart and is for reference only.

Evaluation Criteria **(Example)**	Figures of Merit					
	I	II	III	IV	Weight	Total Influence
Evaluation Criteria - Item 1	1	1	1	5	100	54.1%
Evaluation Criteria - Item 2	1	5	3	5	50	27.0%
Evaluation Criteria - Item 3	1	4	2	5	25	13.5%
Evaluation Criteria - Item 4	1	5	1	5	10	5.4%

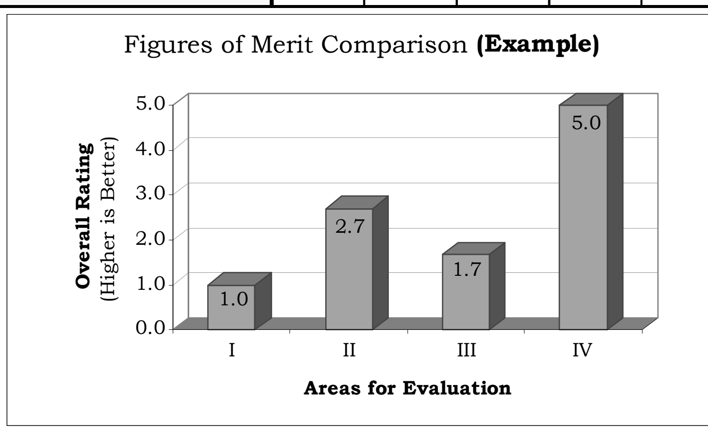


Figure 50: Example of Figure of Merit Evaluation Table & Chart

7.1 Further Evaluation Criteria and Discussion

The evaluation criteria used is based on important considerations that need to be taken in to account during the site selection process. In all instances possible mitigation exists to resolve the conflict. The level of complexity for that mitigation or difficulty may very from site to site.

Range Safety Lines of Sight

These are the Lines of Sight (LOS) from the CCAFS/KSC launch pads to the Range Safety Operations Control Center (ROCC). The candidate pads need to obtain a line of sight to the ROCC. All safety related items were weighted at 100. For some areas the LOS from the ROCC had a higher likelihood of being obstructed from existing facilities. The areas that had LOS obstructions, such as the VAB, received lower scores.

KSC Communication / Instrumentation Lines of Sight

These are the lines of sight from the proposed pads to the various KSC communication and instrumentation antennae. Perceived difficulty achieving this resulted in a low rating.

Intrusions to Constellation and Other Programs

This is meant to reveal any conflicts between the candidate development areas and the proposed Constellation Program facilities. None were found, although area A is located the closest to known Constellation infrastructure and would have the highest likelihood of minor intrusions.

Limitations from Constellation and Other Programs

This is meant to reveal any limitations or intrusions to the proposed new vertical launch facility and operations from the Constellation Program. No significant limitations were identified, although the likelihood of some limitations imposed by the constellation program is highest at Area A because of its proximity to LC-39A.

Over-flight of existing facilities

The issue of over-flight of existing facilities on CCAFS and KSC radically limited the amount of land available for study. The lines drawn from existing facilities are not the "clear" lines but must be evaluated for specific vehicles when that data becomes known. Lower ratings were given to candidate areas with higher potential of over-flight concerns. This included all areas that were not adjacent to the ocean shoreline.

Contiguous Un-submerged Land

Areas with a higher density of submerged lands received the lowest ratings while areas with the largest amount of contiguous un-submerged land received the highest ratings.

Precluded public use areas

The development of areas north of Playalinda Beach Road may have an effect on the current public use of certain areas. A lower rating will be given to any candidate area that has potential of closing or relocating any public use areas.

Proximity to public populated areas

A lower rating is given to candidate areas that are closer to a publicly inhabited area than those that are farther away.

Proximity to usable: road, rail, barge dock, aircraft runway

Higher ratings in these categories were a response to smaller comparative distances from the respective transport means. Short distances to all these items were deemed positive for vehicle component transportation.

Environment

Environmental evaluation criteria includes wetlands, fauna, and pollution/contamination. Areas that are identified as having a larger concentration of wetlands received lower ratings than those with more uplands. Areas identified as prime habitat for scrub jay, gopher tortoise, bald eagle, or other threatened species received a lower rating than those areas with less. Wetlands and Scrub Jay habitat information was gathered from the KSC Master Plan as well as discussions with KSC Environmental Personnel.

Archeological

Depending on the density of cultural and historical resources located at or near each of the areas, there may be an impact to design, location, and schedule of a construction project. A higher rating is given to areas with a lower probability of archeological constraints.

Utilities/Commodities

Each launch site will require utilities and commodities such as Water, Power, Communication Connections, Sewer, and Natural Gas. Some areas have these utilities nearby and others do not. The KSC Master Plan provides information about the locations and types of the utilities. A higher rating is given to areas that have the utility or commodity in the vicinity, and a lower rating is given to areas that will require significant effort to add the utility or commodity to the site.

Aerospace Commodities

Both GN2 and GHe are piped to LC-39A which would provide potential access to areas in the vicinity. For all other areas, these commodities could be trucked-in and stored on-site. High pressure gas lines would have to be run out to the pads from the tank farm. A higher rating is given to areas in the proximity of existing high pressure gas lines.

Transportation Improvements

Improvements to transportation infrastructure are dependant on both requirements of the launch vehicle components and the relative distance of the new facility to existing transportation infrastructure. For the purposes of this study a higher rating is given to locations that have existing infrastructure nearby or have a greater ease of providing access to the various transportation methods. Transportation improvements are compared for Roads, Bridges, Aircraft Runways, and a Barge Dock.

Civil Sitework

Some locations required more civil sitework than others to prepare an area for the addition of launch facilities. A higher rating is given to locations that require the least amount of civil sitework to achieve the same level of preparedness.

Inside Existing KSC Fence

While the official KSC property line extends as far north as Volusia County, the existing security fence is only erected as far north as Playalinda Beach Road. The development of launch facilities north of the existing KSC security fence will require an operational security system be installed that matches the existing level of security provided inside the KSC fence. A rating of 5 is given to all locations that are 100% inside of existing KSC security fence and a rating of 1 is given to locations that are 100% outside the fence because of the isolated location, non-contiguous with the existing security area.

Construction Badging Flexibility

For construction occurring outside of the existing KSC security fence, certain construction flexibilities exist that can have an effect on cost and schedule. Security might not be fully developed until after construction thus reducing the administration and non-work time endemic to security procedures. A higher rating is given to locations outside the existing KSC security fence.

Category 3 Hurricane Tidal Surge

Some locations are naturally more resistant to category 3 hurricane tidal surges as a result of their existing elevations. A higher rating is given to locations which are least effected by the tidal surge of a category 3 hurricane.

Proximity to Salt Laden Air (Corrosion)

Corrosion control of launch facilities is a recurring cost that can be reduced be locating a facility further from salt laden air and the coastline. Experience has shown that launch facilities near the cost (such as LC-39A) experience more corrosion than those further away (such as the VAB). A higher rating is given to locations that are further from salt laden air.

Explosive Quantity Distances

A higher rating is given to locations where the quantity distances of stored propellants, integrated vehicles, and fueled vehicles have the lowest impact on existing facilities and public transportation routes.

7.2 Results of Further Evaluation

The first step in the evaluation was to determine the relative merit of each of the four remaining Areas, A, D, E, and F. “Weight” ratings were then applied to all the evaluation criteria. Safety related items were given the highest weight and items that are easier to mitigate were given the lowest weights. Next, the total influence was calculated based on the relative weight of each line item with respect to the sum of all the weights. Finally, a value of 1 to 5 was assigned to each area.

Table 12: Area Evaluation - Figures of Merit

Evaluation Criteria	Figures of Merit					
	A	D	E	F	Weight	Total Influence
Range Safety Lines of Sight (LOS)	3	1	4	2	100	10.8%
KSC Communication /Instrumentation LOS	4	4	4	2	40	4.3%
Intrusions to Constellation and Other Programs	4	5	5	5	70	7.5%
Limitations from Constellation and Other Programs	2	5	5	5	70	7.5%
Overflight of existing facilities	5	3	3	3	100	10.8%
Contiguous Unsubmerged Land	4	1	3	3	40	4.3%
Precluded public use areas	5	2	2	2	30	3.2%
Proximity to public populated areas	5	3	3	2	100	10.8%
Proximity to usable:						
Road	4	3	5	5	10	1.1%
Rail	5	3	2	1	10	1.1%
Barge Dock	5	2	2	1	10	1.1%
Aircraft Runway	2	4	4	3	10	1.1%
Environment						
Wetlands	3	1	3	3	30	3.2%
Fauna (Scrub Jay, Gopher Tortoise, etc)	1	3	4	4	30	3.2%
Pollution/Contamination	5	5	5	5	30	3.2%
Archeological Constraints	3	3	3	3	10	1.1%
Utilities/Commodities						
Water	5	1	1	1	10	1.1%
Power	5	3	5	5	10	1.1%
Communication (Wire & Fiber Optics)	3	1	1	1	10	1.1%
Sewer	1	1	1	1	10	1.1%
Natural Gas	3	1	1	1	10	1.1%
Aerospace Commodities						
GN2	5	1	1	1	10	1.1%
GHe	3	1	1	1	10	1.1%
Transportation Improvements						
Roads	3	1	3	3	10	1.1%
Bridges	4	5	5	5	10	1.1%
Aircraft Runway	5	5	5	5	10	1.1%
Barge Dock	5	5	5	5	10	1.1%
Civil - Sitework	3	1	3	3	40	4.3%
Inside Existing KSC Security Fence	5	1	1	1	20	2.2%
Constuction Badging Flexibility	1	5	5	5	10	1.1%
Category 3 Hurricane Tidal Surge	5	1	1	1	10	1.1%
Proximity to Salt-Laden Air (Corrosion)	1	2	2	2	10	1.1%
Explosive Quantity Distances						
Propellant Storage	4	4	4	4	10	1.1%
Integrated Vehicle	4	4	4	4	10	1.1%
Fueled Vehicle	3	4	4	4	20	2.2%

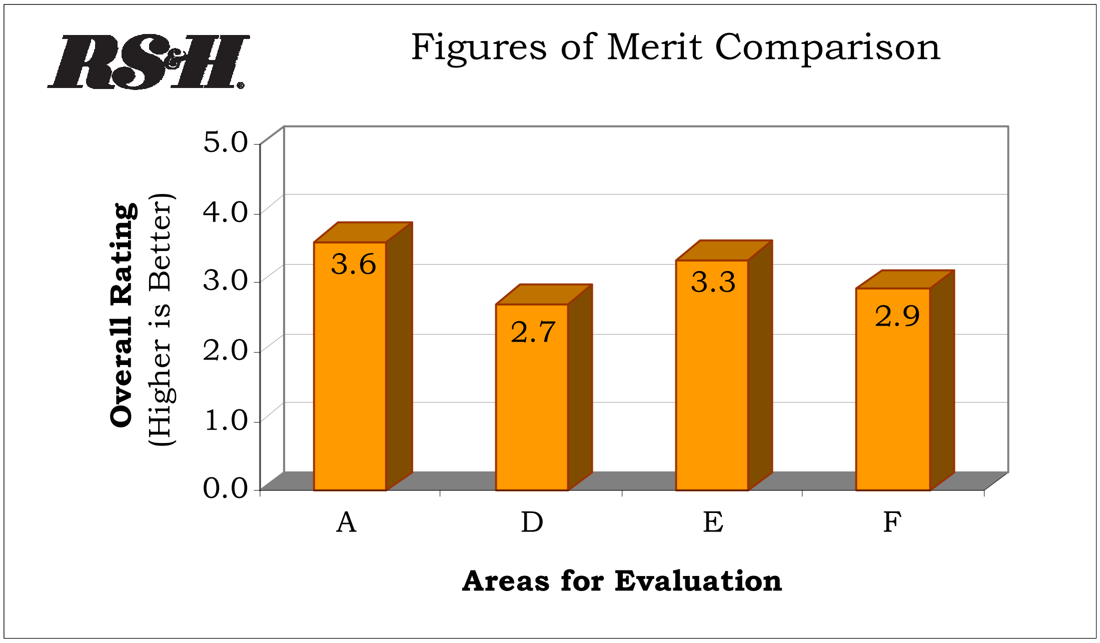


Figure 51: Figures of Merit Comparison

The results of the further evaluation show that Area A received the highest score. Of the four areas considered for further evaluation, Area D received the lowest score. Based on these results, Area A and E are recommended for development of a new site. Conceptual layouts for both Areas A and E have been developed and are shown in Section 10.

Section VIII: Cost Estimates

This section provides cost estimates for the two areas receiving the highest ratings in the evaluation concluded in the previous section.

8.1 Overall

The cost estimates represented here are Rough Order of Magnitude (ROM) estimates. They are in 2007 dollars. They are based upon criteria estimated from the best information available. The estimates are speculative and useful for ROM overall cost diagnosis and for comparison one to another. They are not to be construed as construction estimates. The costs derived herein are based on previous government costs for similar facilities and services.

The estimates are separated into two categories and several sub categories:

- Area A
  Each large user specific item is noted with a separate line item but all are included in the total
  - Two 1Mlb thrust class users (K-1 class)
  - Two 2Mlb thrust class users
    The 2Mlb cost estimate is a specific line item percentage escalation of the previous 1Mlb estimate.
- Area E
  Each large user specific item is noted with a separate line item but all are included in the total
  - Two 1Mlb thrust class users (K-1 class)
  - Two 2Mlb thrust class users
    The 2Mlb cost estimate is a specific line item percentage escalation of the previous 1Mlb estimate.

Additionally three comparative additive alternate options for rail service, barge service and the addition of ATDC office and control accommodations to each site are offered but are not included in the totals.

These estimates include the basic site development and facilities infrastructure to support the candidate vehicle. The cost estimates do not include special vehicle handling and processing GSE, software and vehicle specific commodities control skids and panels. The estimates are based on a proprietary RS&H historic cost data base compiled from information on KSC, CCAFS and DOD projects.

8.2 Cost Summary

The summary cost table shown below depicts the cost derived from estimating the construction costs for establishing the necessary ground infrastructure on each site. For clarification, the terms Area and Site are often used to describe the regions analyzed in this study. The term “Area” is used to describe the region of land bounded and identified in Figure 37. The term “Site” is used to describe the portion of the identified area that is developed into a launch complex.

The cost for developing Areas A and E are nearly equal. The sites themselves are however not identical, the total additional cost of their differences is surprisingly equal. A brief list of their differences is presented below.

- Site A has connections to GN2 and GHe pipe; Site E does not.
- Site A has more wetlands mitigation than does Site E.
- Site A has a shorter duct bank distance to the LCC.
- Site E requires more significant security fence additions than Site A.

Table 13: Cost Estimate Summary for Site A and Site E

Cost Estimate Summary		RS&H
Total Facility Cost (in 2007 $Millions)	Site A	Site E
1 Mlb Thrust Vehicle Facility	$507M	$504M
2 Mlb Thrust Vehicle Facility	$590M	$587M

Table 14: Additive Options Cost Summary for Site A and Site E

Additive Options Cost Summary		RS&H
Total Facility Cost (in 2007 $Millions)	Site A	Site E
Barge Dock & Dredging	$26M	$35M
Railroad Extension	$1M	$18M
ATDC Additions and Mods	$9M	$14M

8.3 Detailed Cost Estimate Summaries for Site A & E

The costs presented here are based upon a proprietary RS&H data base of historical cost information obtained from various sources and constantly escalated to current dollar amounts. The amounts are derived through square foot/yard, lineal foot, quantity, etc. comparisons of proposed structures and systems with similar items in the data base. The information in the database comes largely from KSC and CCAFS projects that are executed in the ways normal for the space program to date. The burgeoning group of commercial launch providers has many different methods that are innovative and alleged to be cost effective. It is then anticipated that when eventually dealing with specific rather than generalized historical criteria these costs will be reduced. Further cost reduction can be obtained if ATDC were to become part of the site and their existing commodity tanks are used in lieu of purchasing new tanks.

Table 15 provides a cost comparison between Site A and Site B for the 1 Mlb Thrust Vehicle class. Minor cost differences are apparent between Site A and Site E. These differences are shown in the civil, electrical, and commodities rows. From the cost comparison shown below the cost values are essentially equal and implies that cost is not a factor for selection between Site A and Site E.

Table 15: Facility Cost Site Comparison for 1Mlb Thrust Vehicle

1 Mlb Thrust Vehicle - Facility Cost Details		RS&H
(in 2007 $Millions)	**Site A**	**Site E**
Architectural	$20	$20
Civil	$30	$27
Structural	$309	$309
Electrical	$75	$79
Vehicle Transport	$8	$8
Commodities	$66	$62
Total	**$507**	**$504**

We were to also evaluate the affects of accommodating a 2 million thrust vehicle. In other sections of this study it has been demonstrated that the changes necessary to make this accommodation have been changes of small increment rather than of large magnitude. This is also true in the cost data. To obtain costs for the 2Mlb thrust vehicle an incremental cost adjustment was applied to line items affected by the increase in vehicle size. These costs are shown in Table 16 and it is evident that the majority of the cost increases apply to the structural and commodities rows for the table.

Table 16: Facility Cost Site Comparison for 2Mlb Thrust Vehicle

2 Mlb Thrust Vehicle - Facility Cost Details	RS&H	
(in 2007 $Millions)	Site A	Site E
Architectural	$20	$20
Civil	$30	$27
Structural	$358	$358
Electrical	$77	$82
Vehicle Transport	$10	$10
Commodities	$95	$91
Total	**$590**	**$587**

Section IX: Schedule

This Section contains a development schedule that encompasses the development for a launch site at either Area A or E. At this level of detail, there is no difference in development time between the two site options or between a K-1 class user or a 2 Mlb thrust Vehicle user. A summary of the development schedule is presented in Figure 52. To hasten the arrival of the Operational Readiness Date (ORD), the schedule indicates overlaps in several areas. This will require adept control of releasing design packages and sub-contractor coordination to facilitate a shortened schedule. There are several users, a central control facility and a requirement that all be individually and collectively connected to the Range, the LCC, various instrumentation sites and addressing payload-user connection needs. This is a precedent setting facilities communication problem that will impose lengthened design times.

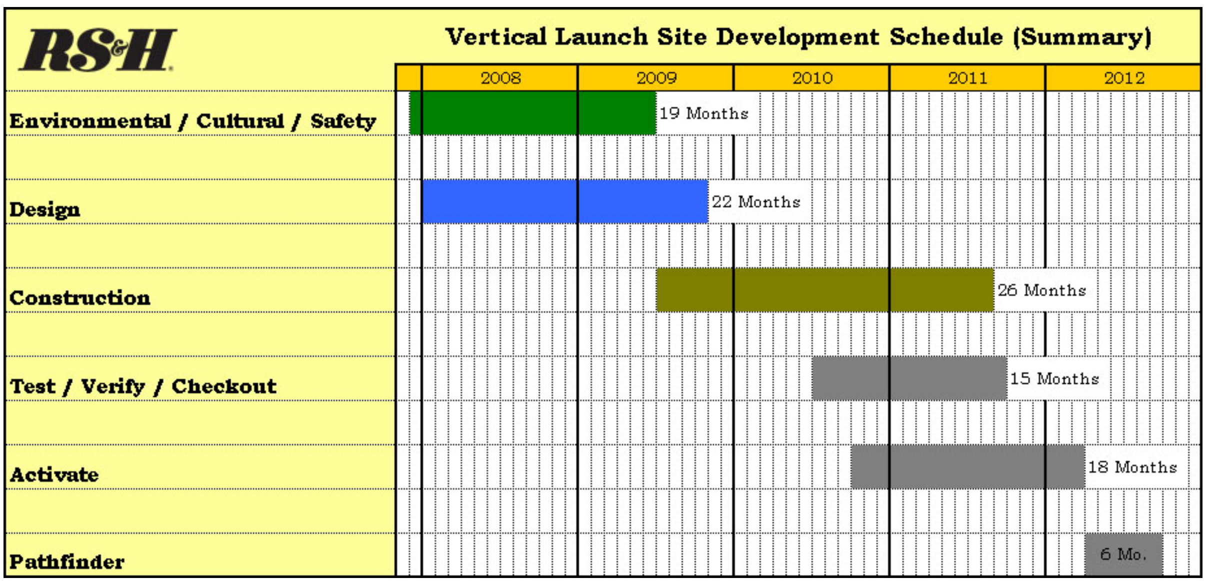


Figure 52: Vertical Launch Site Development Schedule (Summary)

Environmental/Cultural/Range

This includes several requirements such as the Environmental Impact Statement (EIS), the Environmental Baseline Survey (EBS), what cultural surveys and mitigation might be deemed necessary and the KSC/45th Space Wing safety coordination process. These can be performed in parallel.

Design

This item covers all designs required by the site development. Simultaneously meeting the needs of several site users will prolong this process. Developing Interface Control Documentation (ICD) will be the first priority of this endeavor.

Construction

This covers the time allotted for site preparation and installation of infrastructure.

Test/Verify/Checkout

This item includes the contractor verification and demonstration process prior to turnover of specific facilities to the owner.

Activation

Activation is a process that involves the contractor and the owner/user in mutual "ringing down" of systems and facilities.

Pathfinder

This is an owner/user activity that involves verification of systems and facilities compatibility with an actual flight vehicle or a vehicle stand-in.

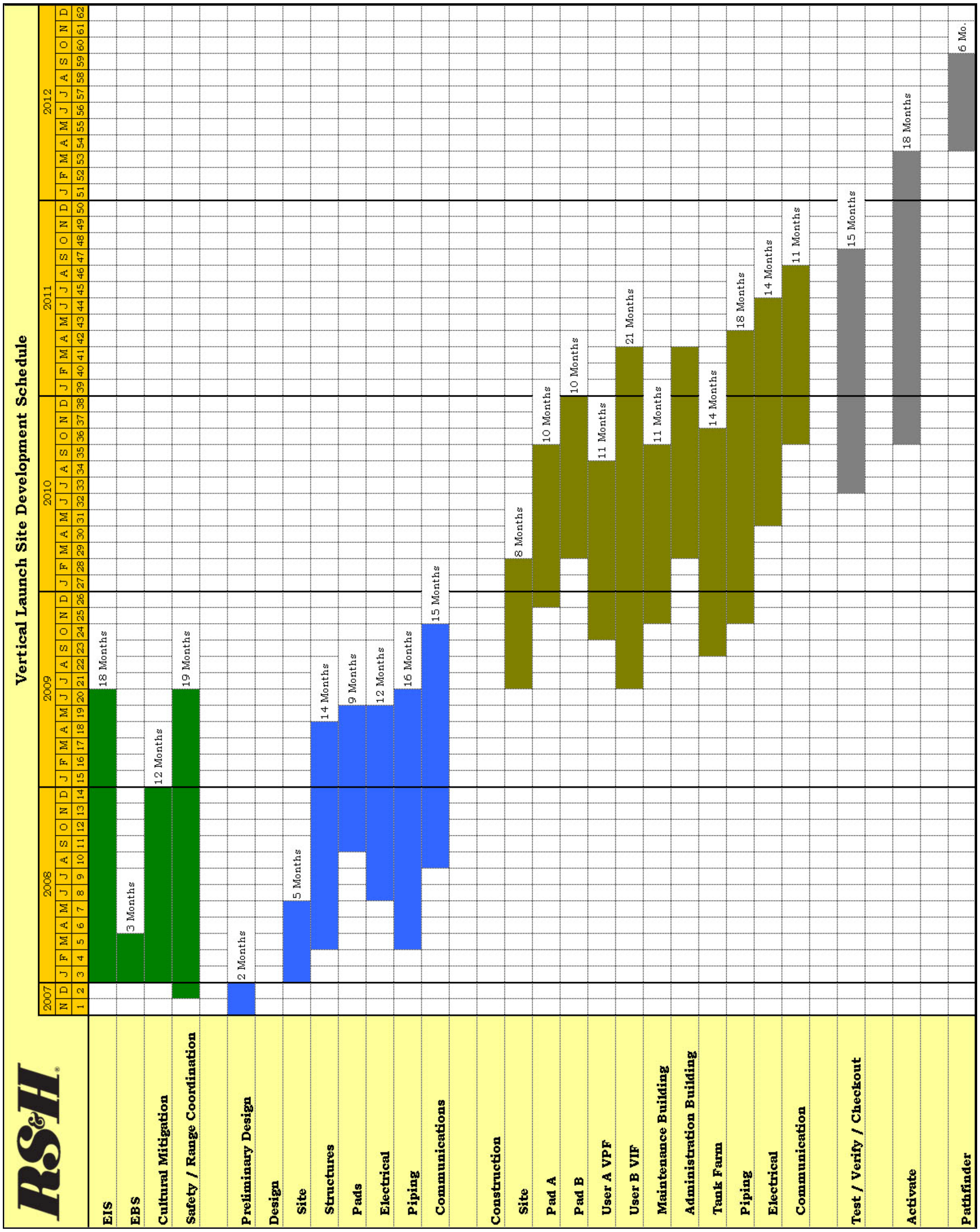


Figure 53: Development Schedule

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Section X: Recommended Vertical Launch Site Options at NASA-KSC

The two highest ranking areas, A and E, that resulted from the Evaluation Matrix, have nearly identical costs and at the level of investigation of this study there is no discernable difference between schedules. Conceptual layouts for each area are shown below.

10.1 Area A

An appropriate suggested location for development of a site in Area A is in the central region and optimizes the use of elevated dry land while maintaining QDs from existing facilities. The developed region is highlighted in Figure 54. A highly conceptual layout sketch of the required ground infrastructure for Area A is shown in Figure 55. The scheme depicted complies with restrictions imposed by the Cx-41 and Pad 39A IBD's. Adherence to the spacing depicted in Figure 7 is only marginally compromised.

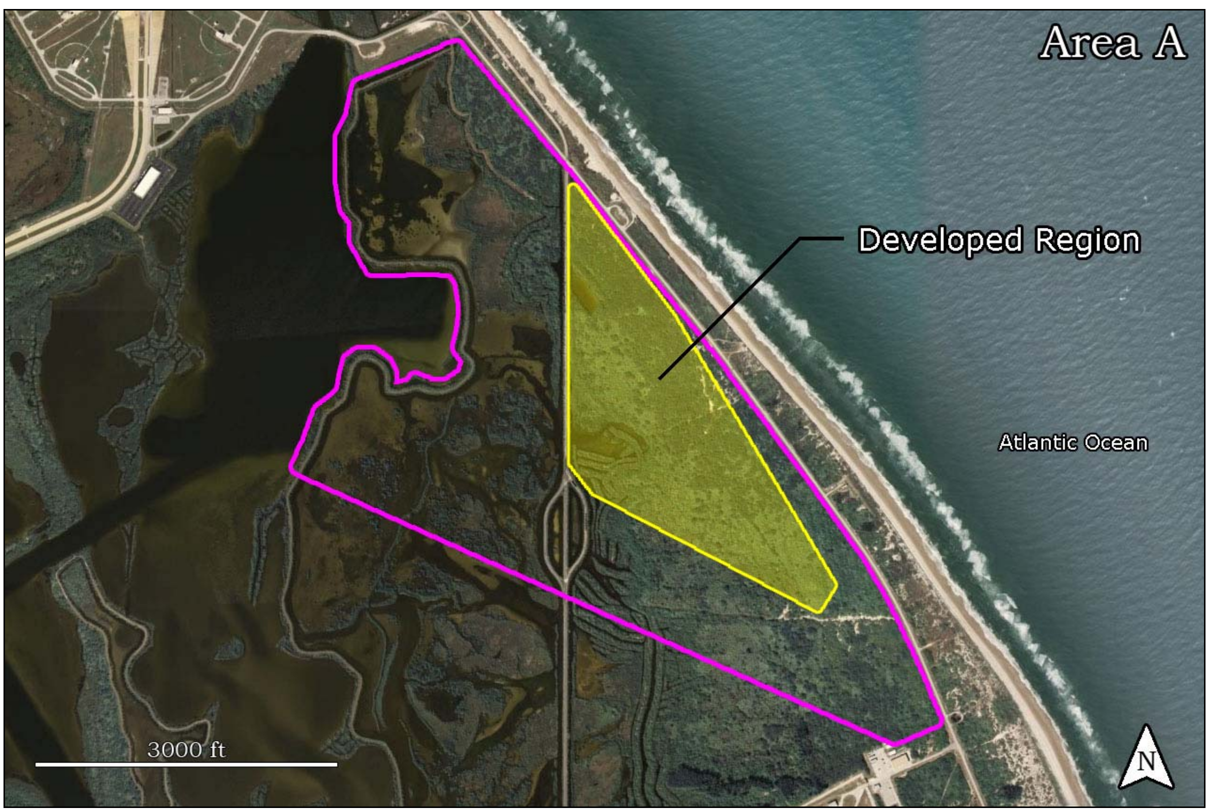


Figure 54: Developed Region for Area A

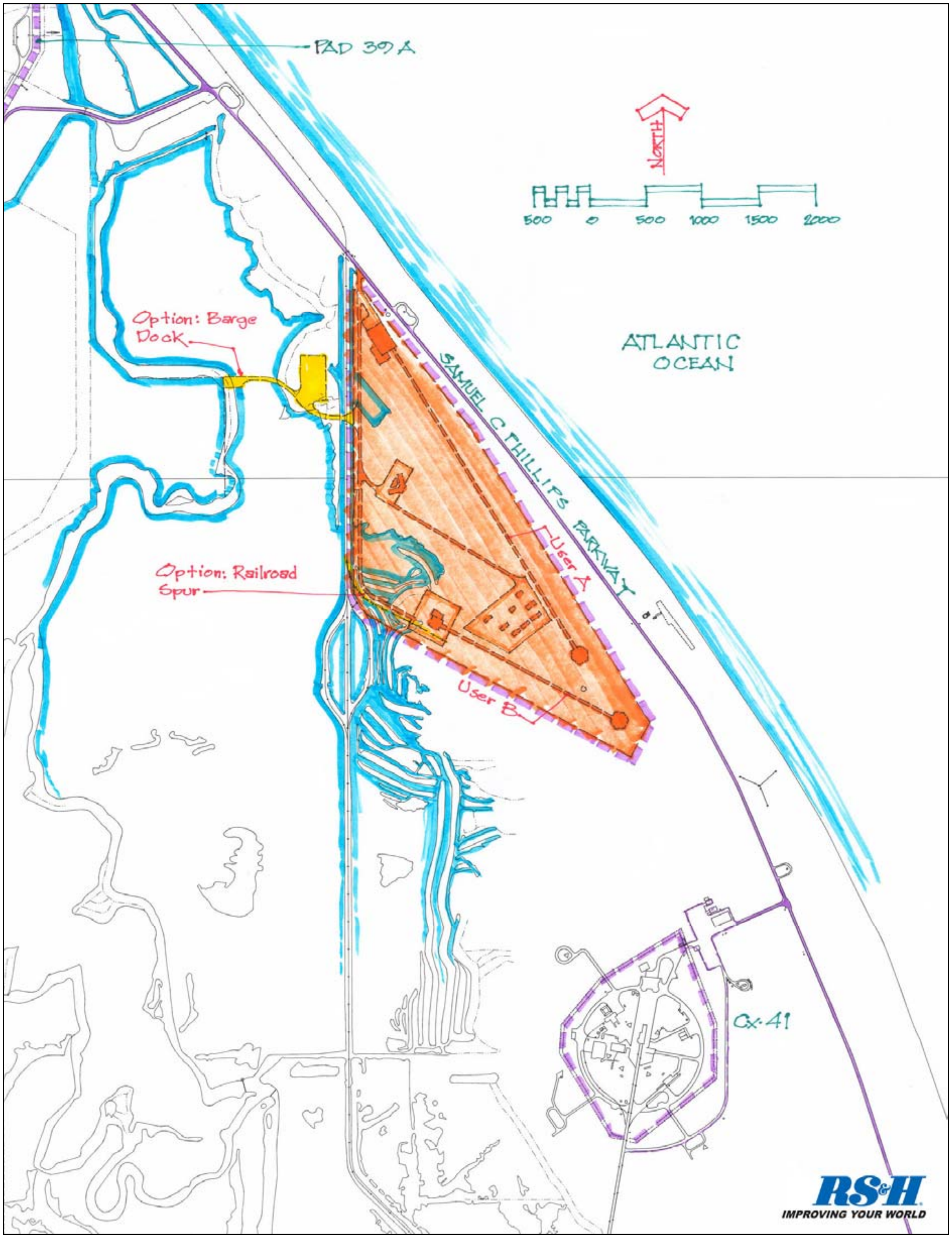


Figure 55: Conceptual Layout for Site A

10.2 Area E

An appropriate suggested location for development of a site in Area E is in the northern region and optimizes the use of elevated dry land while reducing the potential of flyover concerns for existing LC-39B. The developed region is highlighted in Figure 56.

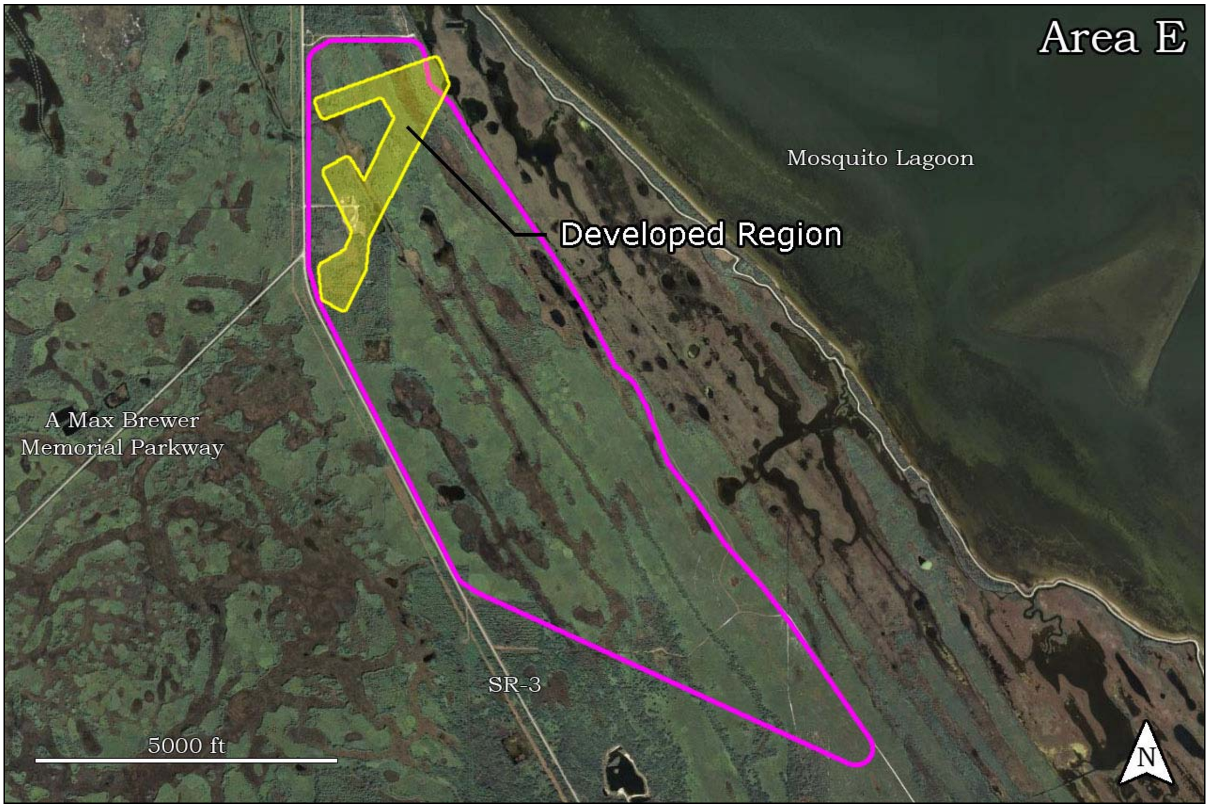


Figure 56: Developed Region for Site E

A highly conceptual layout sketch of the required ground infrastructure for Site E is shown in Figure 57. Adherence to the spacing depicted in Figure 7 is only marginally compromised.

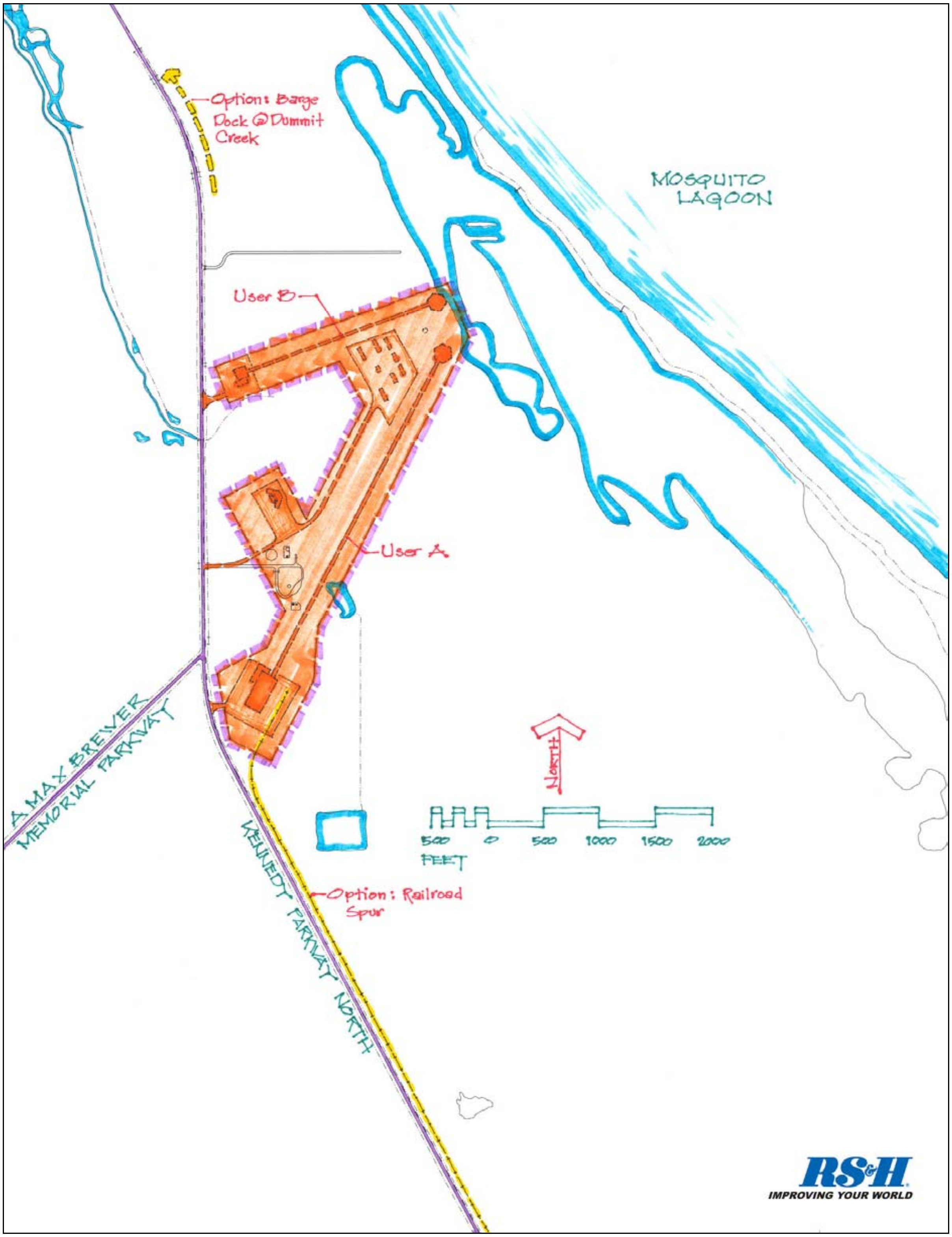


Figure 57: Conceptual Layout for Site E

10.3 Candidate Site Comparisons

Site A	Site E
Pros: ▪ Generally dry elevated land ▪ Provides appropriate launch azimuth range ▪ Sufficient area for launch facilities development ▪ Located inside KSC fence ▪ Existing barge canal nearby ▪ Existing railroad siding nearby ▪ Existing GHe pipeline nearby ▪ Existing GN2 pipeline nearby ▪ Existing power line nearby ▪ Alleged to be above category 3 hurricane tidal surge plane	Pros: ▪ Generally dry elevated land ▪ Provides appropriate launch azimuth range ▪ Sufficient area for launch facilities development ▪ Outside KSC fence for construction ▪ Existing power line nearby ▪ Site is 2.5 miles from ocean (corrosive salt laden air) ▪ Low likelihood of development in wetlands
Cons: ▪ Site is hundreds of feet from ocean (corrosive salt laden air) ▪ Large areas of primary and secondary Scrub Jay habitat ▪ High likelihood of development in wetlands ▪ Adjacent to existing launch pads	Cons: ▪ Located outside KSC fence for operations ▪ Existing barge canal twice the distance from site when compared to Site A ▪ All wire and pipe connections from existing KSC areas to new site will cross public transportation corridor ▪ Existing railroad more than 3 miles from site ▪ Small areas of primary and secondary Scrub Jay habitat ▪ Alleged to be below category 3 hurricane tidal surge plane ▪ Over-flight of publicly accessible areas of Canaveral National Seashore and Mosquito Lagoon.

Selected Candidate Site pro's and con's are discussed below.

Launch Site at Area A

Pro's

- Site A is inside the KSC fence. As such it is afforded the blanket security common to all CCAFS/KSC facilities.
- It is adjacent to a previously dredged but never constructed barge facility. Connection to the existing and currently used ET barge-way is but a short distance. Use of this opportunity will require re-dredging the delineated barge-way as it has surely filled-in in the ensuing forty years since initial dredging.
- It is adjacent to two currently active heavy railed rail road sidings on a spur line that comes from a connection to the mainland.
- GHe is available close by at a pipeline at Pad 39A. Site A cost estimates reflect this connection cost. This raises construction costs but avoids over-the–road deliveries and reduces operations and commodity costs.
- GN2 is available close by from an underground pipeline that runs through the site parallel to Phillips Parkway. Site A cost estimates reflect this connection cost. This raises construction costs but avoids over-the–road deliveries and reduces operations and commodity costs.
- A 13.2/13.8 kva buried electrical power line is available close by under the proposed site.
- Site A is alleged to be dry during a Category 3 hurricane surge.

Con's

- Being inside the fence invokes badging constraints for construction workers and delivery personnel.
- Site A is host to large areas of primary and secondary Scrub Jay habitat. Habitat usurped by construction will have to be mitigated through establishing similar habitat elsewhere at a ratio of 5 established to 1 destroyed.
- Similar to all other KSC/CCAFS launch sites, Site A is only hundreds of feet from the corrosive effects of the salt laden ocean air.
- It might be difficult to design a facility for Site A that does not also impact or destroy wetlands. These compromised lands will be mitigated at a ratio of 10 established to 1 destroyed.
- The proposed site layout shown is at the north end of Site A to avoid the IHB from Cx-41.

Launch Site at Area E

Pro's

- Site E is outside the actual KSC fence. KSC badges need not be a necessary requirement during construction.
- Site E is moderately close to barge-able waterways, however, it is some greater distance than Site A.
- A 13.2/13.8 kva overhead electrical power line is available close by the proposed site, parallel to Kennedy Parkway North.
- Site E is two and a half miles from the corrosive effects of the salt laden ocean air. This will result in reduced maintenance costs compared with launch sites much nearer the ocean.
- The proposed site layout shown is at the north end of Area E to avoid the over-flight restrictions from debris dispersion fields that would be encountered nearer the over-flight line extended from Pad 39B.
- Wetlands are not in abundance in Area E. It is likely possible to design the facility footprint around those that do exist. Any compromised lands will be mitigated at a ratio of 10 established to 1 destroyed.
- The configuration shown for Site E has the potential to obtain some mitigation of contravened habitat by inclusion of newly constructed habitat in the space between the two distinct legs of the layout. To do this properly the facility would have to be designed to tolerate controlled burning of the area at approximately ten year intervals. This is a distinctly experimental approach and is yet to be approved or even evaluated for viability.

Con's

- Site E is outside the KSC fence. As such it is not afforded the blanket security common to all CCAFS/KSC facilities. During construction this could be a positive aspect as mentioned above. After construction, the practical realities of providing a secure location are made difficult with a non-contiguous "outpost" such as Site E.
- Any wire or pipe connection, from the pad to the LCC or commodities, crosses a public transportation corridor unless the corridor, Playalinda Beach Road, is relocated. A launch provider using a site with such compromised security and connectivity is unlikely to anticipate launching any DOD/NRO payloads.
- Should railroad access be desired, it will have to occur via a new spur laid from the railroad spur parallel to Playalinda Beach Road.
- Site E is host to some areas of secondary and smaller areas of primary Scrub Jay habitat. Habitat usurped by construction will have to be mitigated through establishing similar habitat elsewhere at a ratio of 5 established to 1 destroyed.

- All commodities supplied will have to be supplied through over-the–road means.
- Site E is alleged to be submerged during a Category 3 hurricane surge.
- Site E will require over-flight of the public access portion of the Canaveral National Seashore and the public access to Mosquito Lagoon. Additionally, proximity to Kennedy Parkway North, A Max Brewer Parkway and Playalinda Beach Road could pose security problems. All three roads will be closed during fueling and launch operations. There are several possible solutions for this such as moving the roads or precluding public access. The former is expensive and time consuming. The latter will be very unattractive to the public.

10.4 Site Recommendation

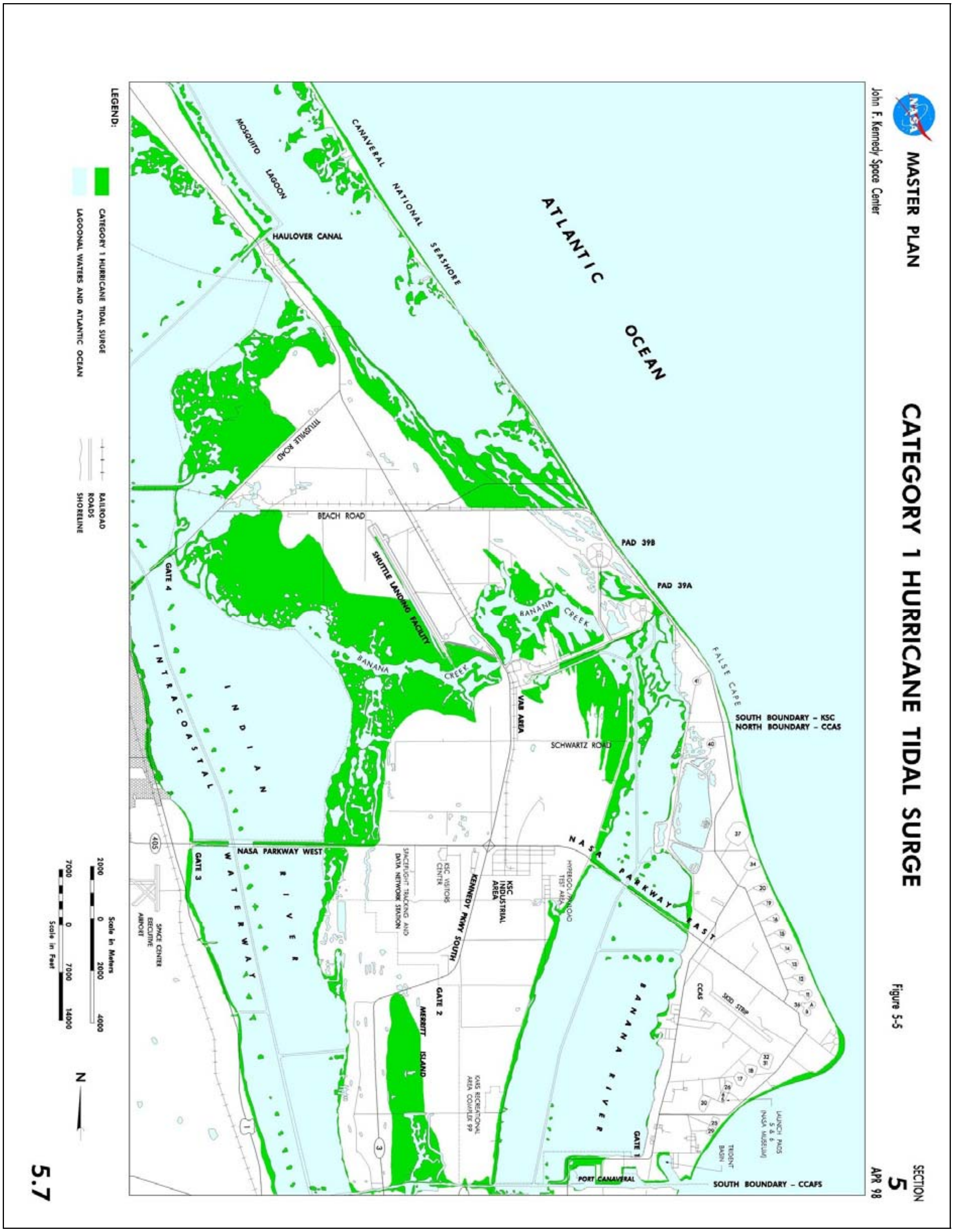
Because of security concerns and proximity to commodities and alternative means of transport, an Area A site is the recommended area for development of a multi-user vertical launch facility. Additionally, use of an Area A site does not adversely affect any public lands.

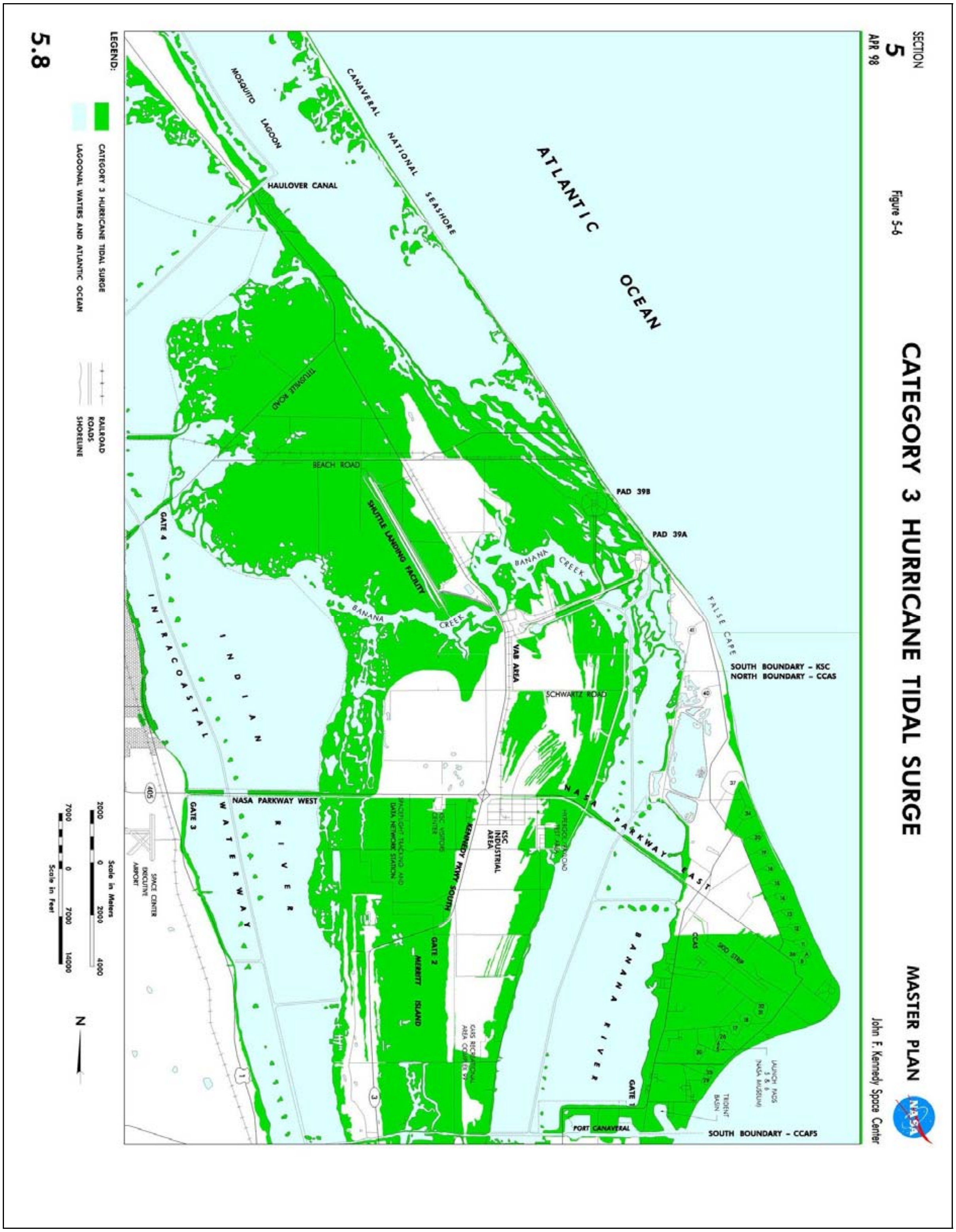
Other Recommendations

1. Obtain specific information from candidate launch providers to clarify and delineate design criteria. This could significantly reduce the conservatively estimated costs and schedules included in this study.
2. Further investigate the recommended site and develop the vertical launch facility with higher fidelity.
3. Investigate the use of temporary buildings and just-in-time delivery of commodities to reduce up-front spending and peaks in spending curves.
4. Investigate the acquisition of the CCAFS area south of Area X to sufficiently enlarge the contiguous land area for site consideration.

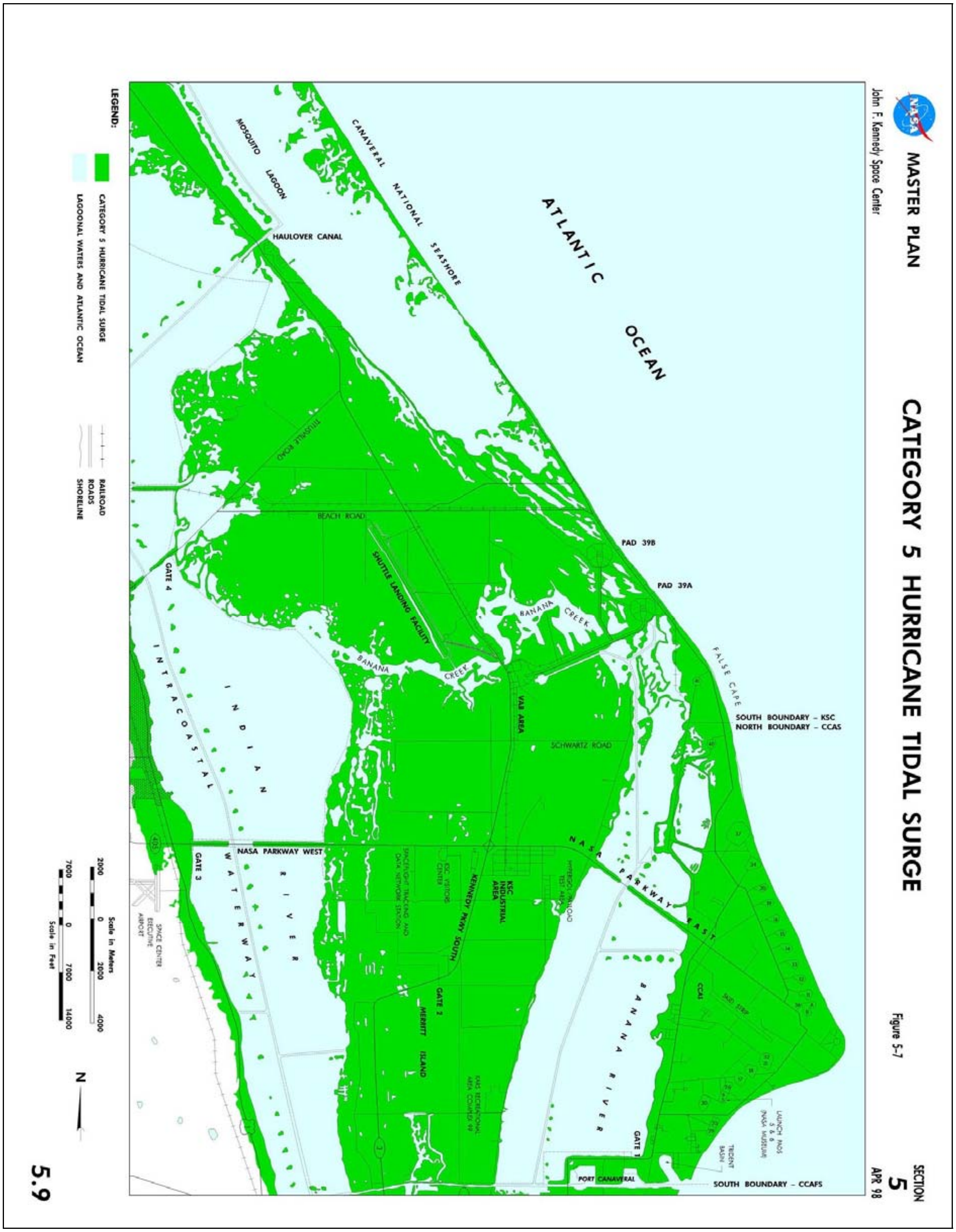
Section XI: Notes and Backup Data

11.1 KSC Master Plan – Hurricane Tidal Surges





SECTION
5
APR 98
Figure 5-6
CATEGORY 3 HURRICANE TIDAL SURGE
MASTER PLAN
John F. Kennedy Space Center
ATLANTIC OCEAN
CANAVERAL NATIONAL SEASHORE
MOSQUITO LAGOON
HAULOVER CANAL
TITUSVILLE ROAD
BEACH ROAD
SHUTTLE LANDING FACILITY
PAD 39B
PAD 39A
BANANA CREEK
FALSE CAPE
SOUTH BOUNDARY - KSC
NORTH BOUNDARY - CCAS
VAB AREA
SCHWARTZ ROAD
GATE 4
INDIAN RIVER
INTRACOASTAL WATERWAY
NASA PARKWAY WEST
NASA PARKWAY EAST
GATE 3
KSC INDUSTRIAL AREA
KENNEDY PKWY SOUTH
GATE 2
MERRITT ISLAND
BANANA RIVER
GATE 1
CCAS
SKID STRIP
PORT CANAVERAL
SOUTH BOUNDARY - CCAFS
TRIDENT BASIN
SPACE CENTER EXECUTIVE AIRPORT
LEGEND:
CATEGORY 3 HURRICANE TIDAL SURGE
LAGOONAL WATERS AND ATLANTIC OCEAN
RAILROAD
ROADS
SHORELINE
Scale in Meters
2000 0 2000 4000
Scale in Feet
7000 0 7000 14000
N
5.8



MASTER PLAN
John F. Kennedy Space Center
CATEGORY 5 HURRICANE TIDAL SURGE
Figure 5-7
SECTION 5
APR 98
LEGEND:
CATEGORY 5 HURRICANE TIDAL SURGE
LAGOONAL WATERS AND ATLANTIC OCEAN
RAILROAD
ROADS
SHORELINE
Scale in Meters
2000 0 2000 4000
Scale in Feet
7000 0 7000 14000
N
ATLANTIC OCEAN
CANAVERAL NATIONAL SEASHORE
MOSQUITO LAGOON
HAULOVER CANAL
BEACH ROAD
SHUTTLE LANDING FACILITY
PAD 39B
PAD 39A
BANANA CREEK
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SOUTH BOUNDARY – KSC
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INTRACOASTAL WATERWAY
INDIAN RIVER
NASA PARKWAY WEST
NASA PARKWAY EAST
GATE 3
KENNEDY PKWY SOUTH
KSC INDUSTRIAL AREA
GATE 2
MERRITT ISLAND
BANANA RIVER
CCAS
GATE 1
PORT CANAVERAL
SOUTH BOUNDARY – CCAFS
5.9

11.2 Backup Cost Data

The cost estimate tables shown on the following pages provide breakdown of cost data used in estimates presented in Section 8. Also provided is a description of the columns used in the cost estimate tables.

(1) Raw Cost

Raw costs are estimated a variety of ways including the use of the proprietary RS&H cost database or from raw data found in cost estimating books such as RS Means.

(2) Payroll Taxes, Insurance, & Sales Tax

The Payroll Taxes, Insurance, and Sales Tax factor is applied to the raw cost. For the purposes of this study it is assumed that labor accounts for 65% of the raw cost and materials account for 35%. A factor of 33% is applied to labor for Payroll taxes and Insurance, while a sales tax of 6% is applied to materials. When combining the labor and materials into one factor a value of 24% is applied to the raw cost.

Formula: (2) = 0.24 * (1)

(3) Prime Overhead

A prime overhead of 15% is assumed for this cost estimate and applied to the sum of all previous columns.

Formula: (3) = 0.15 * [(1) + (2)]

(4) Subcontractor Profit

Subcontractor Profit of 10% is assumed for this cost estimate and applied to the sum of all previous columns.

Formula: (4) = 0.10 * [(1) + (2) + (3)]

(5) Prime Profit

Prime Profit of 10% is assumed for this cost estimate and applied to the sum of all previous columns.

Formula: (5) = 0.10 * [(1) + (2) + (3) + (4)]

(6) Bond

Bond of 1% is assumed for this cost estimate and applied to the sum of all previous columns.

Formula: (6) = 0.01 * [(1) + (2) + (3) + (4) + (5)]

(7) Engineering Estimate

The engineering estimate is the construction cost before a cost adjustment has been applied. The engineering estimate is the sum of all the previous columns.

Formula: (7) = (1) + (2) + (3) + (4) + (5) + (6)

(8) Cost Adjustment

The cost adjustment escalates the engineering estimate to the midpoint of construction. For the purposes of this study an escalation of 8% per year is assumed. It is also assumed that for development of this site the midpoint of construction is 3 years from Aug 2007. This date has been selected based on the schedule and assumes that development of the new site begins immediately. The formula used to determine the escalation factor is as follows.

Escalation Factor = $1.08^N - 1$ where N is the number of years to midpoint of construction. For N = 3, the escalation factor is 26%.

Formula: (8) = 0.26 * (7)

(9) Estimated Construction Contract Price (ECCP)

The Estimated Construction Contract Price (ECCP) is the engineering estimate with a cost adjustment applied.

Formula: (9) = (7) + (8)

(10) Contingency

For the purposes of this study a contingency of 20% is assumed. The contingency is applied to the ECCP value.

Formula: (10) = 0.20 * (9)

(11) Site Engineering and Inspection Services (SEIS)

Formula: (11) = 0.10 * [(9) + (10)]

(12) Design

For the purposes of this study the design is estimated to cost 10% of the sum of the ECCP, Contingency and SEIS.

Formula: (12) = 0.10 * [(9) + (10) + (11)]

(13) Facility Activation, Test and Checkout

From previous experience it has been estimated that the cost to activate, test and checkout a facility is approximately 15% of the sum of the ECCP, Contingency, SEIS, and Design.

Formula: (13) = 0.15 * [(9) + (10) + (11) + (12)]

(14) GSE Activation, Test and Checkout

From previous experience it has been estimated that the cost to activate, test and checkout GSE is approximately 35% of the sum of the ECCP, Contingency, SEIS, and Design.

Formula: (14) = 0.35 * [(9) + (10) + (11) + (12)]

(15) Total

The Total Estimated Cost for each line item takes into account all of the previous listed factors and provides a better indicator of what the actual cost will be in the end.

Formula: (15) = (9) + (10) + (11) + (12) + (13) + (14)

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Subject:	KSC Vertical Launch Site Evaluation	Project #:	302-3354-043
Designer:	BSG / ADC / EM	Sheet:	124 of 125
Checker:	DLK	Date:	17AUG07
		Date:	17AUG07

RS&H **Vertical Launch Site - Two User - Cost Estimate** SITE A

Description	Basis of Estimate	(1) Raw Cost	(2) Payroll Taxes, Insurance & Sales Tax	(3) Prime Overhead	(4) Subcontractor Profit	(5) Prime Profit	(6) Bond	(7) Engineering Estimate	(8) Adjustment (Escalation to Midpoint of Construction) 3 Years	(9) Estimated Construction Contract Price (ECCP)	(10) Contingency	(11) Site Engineering and Inspection Services (SEIS)	(12) Design	(13) Facility Activation, Test & Check-out	(14) GSE Activation, Test & Check-out	(15) Total
			24%	15%	10%	10%	1%		26%		20%	10%	10%	15%	35%	
Architectural																
Administration Building	19-0-F-70							$ 1,581,120	$ 410,636	$ 1,991,756	$ 398,351	$ 239,011	$ 262,912	$ 433,804		$ 3,325,834
Maintainence Building	19-0-D-550							$ 1,459,640	$ 379,086	$ 1,838,726	$ 367,745	$ 220,647	$ 242,712	$ 400,475		$ 3,070,305
Access Control	19-0-S-215	$ 90,000	$ 21,600	$ 16,740	$ 12,834	$ 14,117	$ 1,553	$ 156,844	$ 40,734	$ 197,579	$ 39,516	$ 23,709	$ 26,080	$ 43,033		$ 329,917
Pad Support Building User A	19-0-F-70							$ 706,000	$ 183,357	$ 889,357	$ 177,871	$ 106,723	$ 117,395	$ 193,702		$ 1,485,048
Pad Support Building User B	19-0-F-70							$ 706,000	$ 183,357	$ 889,357	$ 177,871	$ 106,723	$ 117,395	$ 193,702		$ 1,485,048
LCC								$ 4,720,000	$ 1,225,841	$ 5,945,841	$ 1,189,168	$ 713,501	$ 784,851	$ 1,295,004		$ 9,928,365
Civil																
Structural Fill	CRY	$ 693,000	$ 166,320	$ 128,898	$ 98,822	$ 108,704	$ 11,957	$ 1,207,701	$ 313,654	$ 1,521,356	$ 304,271	$ 182,563	$ 200,819	$ 331,351		$ 2,540,360
Dredge and Fill	RSM	$ 480,000	$ 115,200	$ 89,280	$ 68,448	$ 75,293	$ 8,282	$ 836,503	$ 217,250	$ 1,053,753	$ 210,751	$ 126,450	$ 139,095	$ 229,507		$ 1,759,557
Site Work	19-0-S-450							$ 11,000,000	$ 2,856,832	$ 13,856,832	$ 2,771,366	$ 1,662,820	$ 1,829,102			$ 20,120,120
Deluge/Sound Suppression Syste	19-0-S-505							$ 565,000	$ 146,737	$ 711,737	$ 142,347	$ 85,408	$ 93,949	$ 155,016		$ 1,188,459
Existing Roads Upgrade (allow)		$ 150,000	$ 36,000	$ 27,900	$ 21,390	$ 23,529	$ 2,588	$ 261,407	$ 67,891	$ 329,298	$ 65,860	$ 39,516	$ 43,467			$ 478,140
Miscellaneous site, Fence etc. (allow)		$ 450,000	$ 108,000	$ 83,700	$ 64,170	$ 70,587	$ 7,765	$ 784,222	$ 203,672	$ 987,893	$ 197,579	$ 118,547	$ 130,402			$ 1,434,421
Environmental Studies																$ 600,000
Environmental Mitigation																$ 2,000,000
Cultural Mitigation (allow)																$ 100,000
Structural																
Pad Foundation User A	19-0-G-75							$ 4,740,000	$ 1,231,035	$ 5,971,035	$ 1,194,207	$ 716,524	$ 788,177	$ 1,300,491		$ 9,970,434
Pad Foundation User B	19-0-G-75/							$ 3,200,000	$ 831,078	$ 4,031,078	$ 806,216	$ 483,729	$ 532,102	$ 877,969		$ 6,731,095
Vehicle Route to Pad User A	19-0-S-370/	$ 1,194,300	$ 286,632	$ 222,140	$ 170,307	$ 187,338	$ 20,607	$ 2,081,324	$ 540,545	$ 2,621,869	$ 524,374	$ 314,624	$ 346,087	$ 571,043		$ 4,377,997
Vehicle Route to Pad User B	19-0-S-370/	$ 671,400	$ 161,136	$ 124,880	$ 95,742	$ 105,316	$ 11,585	$ 1,170,059	$ 303,878	$ 1,473,937	$ 294,787	$ 176,872	$ 194,560	$ 321,023		$ 2,461,180
Vehicle Erector User A	19-0-G-45							$ 6,900,000	$ 1,792,013	$ 8,692,013	$ 1,738,403	$ 1,043,042	$ 1,147,346		$ 4,417,281	$ 17,038,083
VFF Horizontal	19-0-F-500/							$ 28,000,000	$ 7,271,936	$ 35,271,936	$ 7,054,387	$ 4,232,632	$ 4,655,896		$ 17,925,198	$ 69,140,049
VIF Vertical	19-0-F-500/							$ 65,000,000	$ 16,881,280	$ 81,881,280	$ 16,376,256	$ 9,825,754	$ 10,808,329		$ 41,612,066	$ 160,503,685
Umbilical Tower/ Mast User A	19-0-G-150							$ 7,400,000	$ 1,921,869	$ 9,321,869	$ 1,864,374	$ 1,118,624	$ 1,230,487		$ 4,737,374	$ 18,272,727
Umbilical Tower/ Mast User B	19-0-G-155							$ 6,999,000	$ 1,817,724	$ 8,816,724	$ 1,763,345	$ 1,058,007	$ 1,163,808		$ 4,480,659	$ 17,282,543
Launch Mount (X2)	19-0-G-65	$ 658,000	$ 157,920	$ 122,388	$ 93,831	$ 103,214	$ 11,354	$ 1,146,706	$ 297,813	$ 1,444,520	$ 288,904	$ 173,342	$ 190,677		$ 734,105	$ 2,831,547
Electrical																
Lightning Protection	19-0-S-280							$ 5,000,000	$ 1,298,560	$ 6,298,560	$ 1,259,712	$ 755,827	$ 831,410	$ 1,371,826		$ 10,517,335
Site Power	MAP	$ 5,000,000	$ 1,200,000	$ 930,000	$ 713,000	$ 784,300	$ 86,273	$ 8,713,573	$ 2,263,019	$ 10,976,592	$ 2,195,318	$ 1,317,191	$ 1,448,910		$ 5,578,304	$ 21,516,317
Site Communications		$ 7,000,000	$ 1,680,000	$ 1,302,000	$ 998,200	$ 1,098,020	$ 120,782	$ 12,199,002	$ 3,168,227	$ 15,367,229	$ 3,073,446	$ 1,844,068	$ 2,028,474		$ 7,809,626	$ 30,122,843
Grounding (allow)								$ 2,500,000	$ 649,280	$ 3,149,280	$ 629,856	$ 377,914	$ 415,705	$ 685,913		$ 5,258,668
Haz Gas Detection (allow)								$ 2,000,000	$ 519,424	$ 2,519,424	$ 503,885	$ 302,331	$ 332,564	$ 548,731		$ 4,206,934
Duct Banks								$ 1,620,000	$ 420,733	$ 2,040,733	$ 408,147	$ 244,888	$ 269,377			$ 2,963,145
Vehicle Transport																
Horizontal User A - Tugs (allow)								$ 120,000	$ 31,165	$ 151,165	$ 30,233	$ 18,140	$ 19,954	$ 32,924		$ 252,416
Vertical User B - Transporter	19-0-G-120	$ 1,800,000	$ 432,000	$ 334,800	$ 256,680	$ 282,348	$ 31,058	$ 3,136,886	$ 814,687	$ 3,951,573	$ 790,315	$ 474,189	$ 521,608		$ 2,008,190	$ 7,745,874
Commodities																
GHe Connection (allow)								$ 950,000	$ 246,726	$ 1,196,726	$ 239,345	$ 143,607	$ 157,968	$ 260,647		$ 1,998,294
GN2 Connection (allow)								$ 950,000	$ 246,726	$ 1,196,726	$ 239,345	$ 143,607	$ 157,968	$ 260,647		$ 1,998,294
LOX Tanks New	SS-CEs/	$ 493,500	$ 118,440	$ 91,791	$ 70,373	$ 77,410	$ 8,515	$ 860,030	$ 223,360	$ 1,083,390	$ 216,678	$ 130,007	$ 143,007		$ 550,579	$ 2,123,660
LOX Distribution System	SS-CEs/	$ 1,540,000	$ 369,600	$ 286,440	$ 219,604	$ 241,564	$ 26,572	$ 2,683,780	$ 697,010	$ 3,380,790	$ 676,158	$ 405,695	$ 446,264		$ 1,718,118	$ 6,627,026
GN2 Storage New	SS-CEs/	$ 764,000	$ 183,360	$ 142,104	$ 108,946	$ 119,841	$ 13,183	$ 1,331,434	$ 345,789	$ 1,677,223	$ 335,445	$ 201,267	$ 221,393		$ 852,365	$ 3,287,693
GN2 Distribution System	SS-CEs/	$ 1,692,000	$ 406,080	$ 314,712	$ 241,279	$ 265,407	$ 29,195	$ 2,948,673	$ 765,806	$ 3,714,479	$ 742,896	$ 445,737	$ 490,311		$ 1,887,698	$ 7,281,122
GHE StorageNew	SS-CEs/	$ 630,000	$ 151,200	$ 117,180	$ 89,838	$ 98,822	$ 10,870	$ 1,097,910	$ 285,140	$ 1,383,051	$ 276,610	$ 165,966	$ 182,563		$ 702,866	$ 2,711,056
GHe Distribution System	SS-CEs/	$ 1,292,000	$ 310,080	$ 240,312	$ 184,239	$ 202,663	$ 22,293	$ 2,251,587	$ 584,764	$ 2,836,351	$ 567,270	$ 340,362	$ 374,398		$ 1,441,434	$ 5,559,816
Hypergol Fuel Storage	SS-CEs/	$ 916,000	$ 219,840	$ 170,376	$ 130,622	$ 143,684	$ 15,805	$ 1,596,327	$ 414,585	$ 2,010,912	$ 402,182	$ 241,309	$ 265,440		$ 1,021,945	$ 3,941,789
Fuel Distribution System	SS-CEs/	$ 2,750,000	$ 660,000	$ 511,500	$ 392,150	$ 431,365	$ 47,450	$ 4,792,465	$ 1,244,661	$ 6,037,126	$ 1,207,425	$ 724,455	$ 796,901		$ 3,068,067	$ 11,833,974
Hypergol Oxidizer Storage	SS-CEs/	$ 916,000	$ 219,840	$ 170,376	$ 130,622	$ 143,684	$ 15,805	$ 1,596,327	$ 414,585	$ 2,010,912	$ 402,182	$ 241,309	$ 265,440		$ 1,021,945	$ 3,941,789
Oxidizer Distribution System	SS-CEs/	$ 2,750,000	$ 660,000	$ 511,500	$ 392,150	$ 431,365	$ 47,450	$ 4,792,465	$ 1,244,661	$ 6,037,126	$ 1,207,425	$ 724,455	$ 796,901		$ 3,068,067	$ 11,833,974
Ethanol	19-0-F-215							$ 246,000	$ 63,889	$ 309,889	$ 61,978	$ 37,187	$ 40,905		$ 157,486	$ 607,445
ECS / HVAC, Vehicle/Payload	19-0-G-116							$ 941,000	$ 244,389	$ 1,185,389	$ 237,078	$ 142,247	$ 156,471		$ 602,415	$ 2,323,600
Total		$ 31,930,200						$ 212,948,986		$ 268,254,393						$ 507,107,976
Options																
Dredging Barge Route	RSM							$ 2,470,000	$ 641,489	$ 3,111,489	$ 622,298	$ 373,379	$ 410,717			$ 7,629,370
Barge Dock w/ Turn Basin	19-0-F-490							$ 6,100,000	$ 1,584,243	$ 7,684,243	$ 1,536,849	$ 922,109	$ 1,014,320			$ 18,841,764
Railroad Extension	19-0-S-370							$ 470,000	$ 122,065	$ 592,065	$ 118,413	$ 71,048	$ 78,153			$ 1,451,742
ATDC																
LH2 Tanks Existing, recertify			$ -	$ -	$ -	$ -	$ -	$ 100,000	$ 25,971	$ 125,971	$ 25,194	$ 15,117	$ 16,628	$ 27,437	$ 64,019	$ 400,336
LH2 Distribution System	SS-CEs/	$ 750,000	$ 180,000	$ 139,500	$ 106,950	$ 117,645	$ 12,941	$ 1,307,036	$ 339,453	$ 1,646,489	$ 329,298	$ 197,579	$ 217,337		$ 836,746	$ 4,873,936
Administration Building Mods	19-0-F-70		$ -	$ -	$ -	$ -	$ -	$ 1,054,080	$ 273,757	$ 1,327,837	$ 265,567	$ 159,340	$ 175,275		$ 674,807	$ 3,930,664

RS&H Vertical Launch Site - Two User - Cost Estimate — SITE E

Description	Basis of Estimate	(1) Raw Cost	(2) Payroll Taxes, Insurance & Sales Tax	(3) Prime Overhead	(4) Subcontractor Profit	(5) Prime Profit	(6) Bond	(7) Engineering Estimate	(8) Adjustment (Escalation to Midpoint of Construction) 3 Years	(9) Estimated Construction Contract Price (ECCP)	(10) Contingency	(11) Site Engineering and Inspection Services (SEIS)	(12) Design	(13) Facility Activation, Test & Check-out	(14) GSE Activation, Test & Check-out	(15) Total
			24%	15%	10%	10%	1%		26%		20%	10%	10%	15%	35%	
Architectural																
Administration Building	19-0-F-70							$ 1,581,120	$ 410,636	$ 1,991,756	$ 398,351	$ 239,011	$ 262,912	$ 433,804		$ 3,325,834
Maintainence Building	19-0-D-550							$ 1,459,640	$ 379,086	$ 1,838,726	$ 367,745	$ 220,647	$ 242,712	$ 400,475		$ 3,070,305
Access Control	19-0-S-215	$ 90,000	$ 21,600	$ 16,740	$ 12,834	$ 14,117	$ 1,553	$ 156,844	$ 40,734	$ 197,579	$ 39,516	$ 23,709	$ 26,080	$ 43,033		$ 329,917
Pad Support Building User A	19-0-F-70							$ 706,000	$ 183,357	$ 889,357	$ 177,871	$ 106,723	$ 117,395	$ 193,702		$ 1,485,048
Pad Support Building User B	19-0-F-70							$ 706,000	$ 183,357	$ 889,357	$ 177,871	$ 106,723	$ 117,395	$ 193,702		$ 1,485,048
LCC								$ 4,720,000	$ 1,225,841	$ 5,945,841	$ 1,189,168	$ 713,501	$ 784,851	$ 1,295,004		$ 9,928,365
Civil																
Structural Fill	CRT	$ 289,000	$ 69,360	$ 53,754	$ 41,211	$ 45,333	$ 4,987	$ 503,645	$ 130,803	$ 634,447	$ 126,889	$ 76,134	$ 83,747	$ 138,183		$ 1,059,400
Dredge and Fill	RSM	$ 200,000	$ 48,000	$ 37,200	$ 28,520	$ 31,372	$ 3,451	$ 348,543	$ 90,521	$ 439,064	$ 87,813	$ 52,688	$ 57,956	$ 95,628		$ 733,149
Site Work	19-0-S-450							$ 11,000,000	$ 2,856,832	$ 13,856,832	$ 2,771,366	$ 1,662,820	$ 1,829,102			$ 20,120,120
Deluge/Sound Suppression Syste	19-0-S-505							$ 565,000	$ 146,737	$ 711,737	$ 142,347	$ 85,408	$ 93,949	$ 155,016		$ 1,188,459
Existing Roads Upgrade (allow)		$ 150,000	$ 36,000	$ 27,900	$ 21,390	$ 23,529	$ 2,588	$ 261,407	$ 67,891	$ 329,298	$ 65,860	$ 39,516	$ 43,467			$ 478,140
Miscellaneous site, Fence etc. (allow)		$ 607,000	$ 145,680	$ 112,902	$ 86,558	$ 95,214	$ 10,474	$ 1,057,828	$ 274,731	$ 1,332,558	$ 266,512	$ 159,907	$ 175,898			$ 1,934,875
Environmental Studies																$ 600,000
Environmental Mitigation																$ 400,000
Cultural Mitigation (allow)																$ 100,000
Structural																
Pad Foundation User A	19-0-G-75							$ 4,740,000	$ 1,231,035	$ 5,971,035	$ 1,194,207	$ 716,524	$ 788,177	$ 1,300,491		$ 9,970,434
Pad Foundation User B	19-0-G-75/							$ 3,200,000	$ 831,078	$ 4,031,078	$ 806,216	$ 483,729	$ 532,102	$ 877,969		$ 6,731,095
Vehicle Route to Pad User A	19-0-S-370/	$ 1,194,300	$ 286,632	$ 222,140	$ 170,307	$ 187,338	$ 20,607	$ 2,081,324	$ 540,545	$ 2,621,869	$ 524,374	$ 314,624	$ 346,087	$ 571,043		$ 4,377,997
Vehicle Route to Pad User B	19-0-S-370/	$ 671,400	$ 161,136	$ 124,880	$ 95,742	$ 105,316	$ 11,585	$ 1,170,059	$ 303,878	$ 1,473,937	$ 294,787	$ 176,872	$ 194,560	$ 321,023		$ 2,461,180
Vehicle Erector User A	19-0-G-45							$ 6,900,000	$ 1,792,013	$ 8,692,013	$ 1,738,403	$ 1,043,042	$ 1,147,346		$ 4,417,281	$ 17,038,083
VPF Horizontal	19-0-F-500/							$ 28,000,000	$ 7,271,936	$ 35,271,936	$ 7,054,387	$ 4,232,632	$ 4,655,896		$ 17,925,198	$ 69,140,049
VIF Vertical	19-0-F-500/							$ 65,000,000	$ 16,881,280	$ 81,881,280	$ 16,376,256	$ 9,825,754	$ 10,808,329		$ 41,612,066	$ 160,503,685
Umbilical Tower/Mast User A	19-0-G-150							$ 7,400,000	$ 1,921,869	$ 9,321,869	$ 1,864,374	$ 1,118,624	$ 1,230,487		$ 4,737,374	$ 18,272,727
Umbilical Tower/Mast User B	19-0-G-155							$ 6,999,000	$ 1,817,724	$ 8,816,724	$ 1,763,345	$ 1,058,007	$ 1,163,808		$ 4,480,659	$ 17,282,543
Launch Mount (X2)	19-0-G-65	$ 658,000	$ 157,920	$ 122,388	$ 93,831	$ 103,214	$ 11,354	$ 1,146,706	$ 297,813	$ 1,444,520	$ 288,904	$ 173,342	$ 190,677		$ 734,105	$ 2,831,547
Electrical																
Lightning Protection	19-0-S-280							$ 5,000,000	$ 1,298,560	$ 6,298,560	$ 1,259,712	$ 755,827	$ 831,410	$ 1,371,826		$ 10,517,335
Site Power	MAP	$ 5,000,000	$ 1,200,000	$ 930,000	$ 713,000	$ 784,300	$ 86,273	$ 8,713,573	$ 2,263,019	$ 10,976,592	$ 2,195,318	$ 1,317,191	$ 1,448,910		$ 5,578,304	$ 21,516,317
Site Communications		$ 7,000,000	$ 1,680,000	$ 1,302,000	$ 998,200	$ 1,098,020	$ 120,782	$ 12,199,002	$ 3,168,227	$ 15,367,229	$ 3,073,446	$ 1,844,068	$ 2,028,474		$ 7,809,626	$ 30,122,843
Grounding (allow)								$ 2,500,000	$ 649,280	$ 3,149,280	$ 629,856	$ 377,914	$ 415,705	$ 685,913		$ 5,258,668
Duct Bank	19-0-S-485							$ 3,942,000	$ 1,023,785	$ 4,965,785	$ 993,157	$ 595,894	$ 655,484	$ 1,081,548		$ 8,291,867
Haz Gas Detection (allow)								$ 2,000,000	$ 519,424	$ 2,519,424	$ 503,885	$ 302,331	$ 332,564			$ 3,658,204
Vehicle Transport																
Horizontal User A - Tugs (allow)								$ 120,000	$ 31,165	$ 151,165	$ 30,233	$ 18,140	$ 19,954	$ 32,924		$ 252,416
Vertical User B - Transporter	19-0-G-120	$ 1,800,000	$ 432,000	$ 334,800	$ 256,680	$ 282,348	$ 31,058	$ 3,136,886	$ 814,687	$ 3,951,573	$ 790,315	$ 474,189	$ 521,608		$ 2,008,190	$ 7,745,874
Commodities																
LOX Tanks New	SS-CEs/	$ 493,500	$ 118,440	$ 91,791	$ 70,373	$ 77,410	$ 8,515	$ 860,030	$ 223,360	$ 1,083,390	$ 216,678	$ 130,007	$ 143,007		$ 550,579	$ 2,123,660
LOX Distribution System	SS-CEs/	$ 1,540,000	$ 369,600	$ 286,440	$ 219,604	$ 241,564	$ 26,572	$ 2,683,780	$ 697,010	$ 3,380,790	$ 676,158	$ 405,695	$ 446,264		$ 1,718,118	$ 6,627,026
GN2 Storage New	SS-CEs/	$ 764,000	$ 183,360	$ 142,104	$ 108,946	$ 119,841	$ 13,183	$ 1,331,434	$ 345,789	$ 1,677,223	$ 335,445	$ 201,267	$ 221,393		$ 852,365	$ 3,287,693
GN2 Distribution System	SS-CEs/	$ 1,692,000	$ 406,080	$ 314,712	$ 241,279	$ 265,407	$ 29,195	$ 2,948,673	$ 765,806	$ 3,714,479	$ 742,896	$ 445,737	$ 490,311		$ 1,887,698	$ 7,281,122
GHE StorageNew	SS-CEs/	$ 630,000	$ 151,200	$ 117,180	$ 89,838	$ 98,822	$ 10,870	$ 1,097,910	$ 285,140	$ 1,383,051	$ 276,610	$ 165,966	$ 182,563		$ 702,866	$ 2,711,056
GHe Distribution System	SS-CEs/	$ 1,292,000	$ 310,080	$ 240,312	$ 184,239	$ 202,663	$ 22,293	$ 2,251,587	$ 584,764	$ 2,836,351	$ 567,270	$ 340,362	$ 374,398		$ 1,441,434	$ 5,559,816
Hypergol Fuel Storage	SS-CEs/	$ 916,000	$ 219,840	$ 170,376	$ 130,622	$ 143,684	$ 15,805	$ 1,596,327	$ 414,585	$ 2,010,912	$ 402,182	$ 241,309	$ 265,440		$ 1,021,945	$ 3,941,789
Fuel Distribution System	SS-CEs/	$ 2,750,000	$ 660,000	$ 511,500	$ 392,150	$ 431,365	$ 47,450	$ 4,792,465	$ 1,244,661	$ 6,037,126	$ 1,207,425	$ 724,455	$ 796,901		$ 3,068,067	$ 11,833,974
Hypergol Oxidizer Storage	SS-CEs/	$ 916,000	$ 219,840	$ 170,376	$ 130,622	$ 143,684	$ 15,805	$ 1,596,327	$ 414,585	$ 2,010,912	$ 402,182	$ 241,309	$ 265,440		$ 1,021,945	$ 3,941,789
Oxidizer Distribution System	SS-CEs/	$ 2,750,000	$ 660,000	$ 511,500	$ 392,150	$ 431,365	$ 47,450	$ 4,792,465	$ 1,244,661	$ 6,037,126	$ 1,207,425	$ 724,455	$ 796,901		$ 3,068,067	$ 11,833,974
Ethanol	19-0-F-215							$ 246,000	$ 63,889	$ 309,889	$ 61,978	$ 37,187	$ 40,905		$ 157,486	$ 607,445
ECS / HVAC, Vehicle/Payload	19-0-G-116							$ 941,000	$ 244,389	$ 1,185,389	$ 237,078	$ 142,247	$ 156,471		$ 602,415	$ 2,323,600
Total								$ 212,452,575		$ 267,629,058						$ 504,284,466
Options																
Dredging Barge Route	RSM							$ 5,098,000	$ 1,324,012	$ 6,422,012	$ 1,284,402	$ 770,641	$ 847,706			$ 15,746,773
Barge Dock w/ Turn Basin	19-0-F-490							$ 6,100,000	$ 1,584,243	$ 7,684,243	$ 1,536,849	$ 922,109	$ 1,014,320			$ 18,841,764
Railroad Extension	19-0-S-370							$ 5,728,000	$ 1,487,630	$ 7,215,630	$ 1,443,126	$ 865,876	$ 952,463			$ 17,692,726
ATDC																
LH2 Tanks Existing, recertify			$ -	$ -	$ -	$ -	$ -	$ 100,000	$ 25,971	$ 125,971	$ 25,194	$ 15,117	$ 16,628	$ 27,437	$ 64,019	$ 400,336
LH2 Distribution System	SS-CEs/	$ 1,500,000	$ 360,000	$ 279,000	$ 213,900	$ 235,290	$ 25,882	$ 2,614,072	$ 678,906	$ 3,292,978	$ 658,596	$ 395,157	$ 434,673		$ 1,673,491	$ 9,747,873
Administration Building Mods								$ 1,054,080	$ 273,757	$ 1,327,837	$ 265,567	$ 159,340	$ 175,275	$ 289,203		$ 3,545,060